Traffic Quarterly

TABLE OF CONTENTS, APRIL 1948

Groping 115
COLONEL ROBERT C. F. GOETZ

Research in Traffic Engineering 119
ROGER L. MORRISON

Two-Way, Non-Stop Cross-Traffic is Proposed for Cities . . 128
PIERRE ZANNETTOS

Traffic Factors in Bridge Planning 152
M. EARL CAMPBELL

Fringe Lots, Garages, Shuttle Buses Ease Congested Washington Parking 163
P. Y. K. HOWAT

The City Means Nothing to Traffic 175
PETER P. HALE

The Uses of Accident Records in a State Traffic Program . . 183
CAPTAIN W. L. GROTH

Cyclists Complicate Urban Traffic in the Netherlands . . 193
DR. J. G. RAMAKER

Traffic Accidents in 1947 204
SIDNEY J. WILLIAMS

Everyone Has a Personal Stake in His City's Parking Problems 208
F. WARREN LOVEJOY

Copyright 1948, by the Eno Foundation for Highway Traffic Control, Inc.

Published quarterly by the Eno Foundation at Saugatuck, Conn., issue for April, 1948.
Printed in U. S. A.

Research in Traffic Engineering

ROGER L. MORRISON

Mr. Morrison is Professor of Highway Engineering and Highway Transport, in charge of the Division of Transportation Engineering, at the University of Michigan. He has served as chairman of the Highway Division of the American Society of Civil Engineers; general chairman of the Traffic Section of the National Safety Council; president of the Institute of Traffic Engineers, and chairman of the Highway Research Board. Professor Morrison is a member of the Board of Consultants of the Eno Foundation.

OCCASIONALLY some important scientific fact is discovered quite by accident, as when Newton established the law of gravity as a result of the chance falling of an apple, and Goodyear accidentally discovered a successful method of vulcanizing rubber. Almost all of the progress, however, in the field of science, including engineering, has been through painstaking experimentation and analysis. In other words developments and improvements have come through research.

Even the accidents that have been the basis of great discoveries have usually, if not always, been observed by persons of long experience in seeking additions to scientific knowledge through study and experimentation. The falling of countless billions of apples had been seen by billions of people during thousands of years without anyone's suggesting the existence of such a force as gravity.

It was only when the accidental dropping of an apple from a tree started a train of thought *in the mind of a great researcher* that gravitation was discovered. Goodyear had spent many years in research with India rubber before an accident led to vulcanizing. Of course it is possible for anyone to make an observation or have an idea which will result in the improvement of some device or method, but most engineering progress must come through research.

It is said that the most successful manufacturing companies are those that do the most research. Certainly the largest corporations in America have extensive research facilities manned by highly trained personnel. Many are also continually having investigations

made by members of university faculties, almost every field of human knowledge being involved in their different studies. This great variety of commercial problems is illustrated by a case in which a member of an astronomy faculty was called upon to test with a seismograph the effect of nearby quarry-blasting upon a residence as compared with similar effects of large trucks passing the house.

If the rate of growth of corporations could be plotted against the percentage of their income devoted to research it appears probable that a definite relationship would be shown, the rate of growth increasing with research.

The Federal Government, some states and a few cities as well as some colleges, have engaged in highway research for many years, with an increasing interest in traffic engineering studies. In general, however, development of the vital activity of handling traffic on city streets and rural roads, which affects the convenience and safety of nearly every citizen, has been vastly different from that, say, of the vehicles using the highways.

Gruelling tests of every important part of a motor vehicle, and of the completed vehicles, are being made day and night at the factories, on the proving grounds and on the highways. Careful and detailed records are kept of every test. As a result of these records, new improvements are planned. These in turn are tested and again improved, in a never-ending sequence. No suggested change is made without engineering study, because some untrained and uninformed stockholder or vehicle owner has a scheme he thinks is good.

It is to be hoped that the time will come when this will be true of traffic engineering matters. Much progress is being made. But so far, the need for engineering study and research on any traffic matter is hardly recognized at all by the general public, and little by public officials.

Recently, in one of our largest and most progressive cities, a highly technical matter involving the use of pedestrian islands was about to be determined by what amounted to popular vote. That is, the city council and various officials, without training in traffic engineering, were to settle the question. Newspaper accounts did not indicate that any of them had suggested further research on the design and protection of the islands, or even any study of detailed

statistics of all accidents occurring on the street before and after the installation of the islands. Perhaps the news stories gave a wrong impression, but if there had been any serious demand for a scientific approach to the problem, it is probable it would have been mentioned. Certainly most citizens seem to feel capable of prescribing for all traffic difficulties without assistance from those engaged in traffic studies.

Development of Traffic Engineering Research

In spite of public apathy, a few pioneers began more than twenty years ago to use research methods in studying their traffic problems. Half a century ago, William Phelps Eno, included in his wide-spread traffic activities many studies classed as research.

It is, perhaps, not generally known that a detailed survey of traffic and transportation in London, England, was made in 1904 by a Royal Commission on London Traffic. They employed an Advisory Board of Engineers consisting of Sir John Wolfe Wolfe-Barry, K.C.B., Sir Benjamin Baker, K.C.B., and General William Barkley Parsons of New York. Wolfe-Barry was a past president of the Institution of Civil Engineers. Baker was designer of the great Forth Bridge in Scotland, the Assuan Dam in Egypt, the ship that brought the obelisk, Cleopatra's Needle, from Egypt to New York City, and other well-known engineering works, including the first shield for tunneling under rivers.

Although this was primarily an investigation of tramway problems, it included what was perhaps the first extensive street-traffic survey ever made. The report was published in eight volumes of about 1000 pages each. It is of interest that the London officials more than forty years ago realized that street-traffic problems were largely engineering in nature and of sufficient importance to merit the attention of one who was probably the outstanding civil engineer in Great Britain; also that they obtained the services of one of the leading civil engineers of America as an advisor during the survey.

Actually the early traffic surveys, including those made in the '20s by the U. S. Bureau of Public Roads, the Harvard Bureau, the National Safety Council, and others, were begun with so little as a guide in the way of previous experience that they might be con-

sidered more as research projects than as merely routine gathering and compilation of facts about local traffic.

In 1925, the Bureau of Street Traffic Research was established at Harvard University. In 1938, it was moved to Yale University where it is now known as the Bureau of Highway Traffic. This bureau has been able to do research in ever-increasing volume. In recent years, its close affiliation with the Eno Foundation, established in 1921 has still further increased its opportunities.

Modern wars are, of course, fought at a terrific cost in human lives and injuries, in depletion of natural resources, in destruction of property, and in money; but on the other hand, each war serves as a stimulus to research in many lines. One result of our Civil War was the establishment of the National Academy of Sciences through which the war efforts of all the leading scientists were correlated. During World War I, the National Research Council was formed as part of the Academy of Sciences. This was primarily a further war measure, but it has served and grown through war and peace. It extends into many fields. One is covered by the Division of Engineering and Industrial Research, and under the auspices of this division, the Highway Research Board was organized in 1920.

The Highway Research Board

This Board functioned mainly through committees and subcommittees, with the organization being revised from time to time. In 1922, a Committee on Highway Traffic Analysis was organized; in 1926, a Special Committee on Causes and Prevention of Highway Accidents was formed. A year later, this became one of the seven main committees. In 1930, the two committees were merged and became the Committee on Traffic, with eleven subcommittees. In 1935, the main committees were changed into departments. One of them was the Department of Traffic and Safety—for the last four years, the Department of Traffic and Operations.

Under the terms of a recent Federal Aid Act, it became possible for state highway departments to assist in financing the Highway Research Board. With the substantial increase in funds the board employed a staff of technical experts and inaugurated a correlation

service, to contact state highway departments. These engineers encourage research, correlate various research activities and assist in applying the results of research to current problems. A traffic engineer was recently added to this staff.

From this record we see that twenty-six years ago a research committee was set up to study traffic. That was four years before a single full-time traffic engineer was employed anywhere in the country. Evidently at that early date, there were a few highway engineers who recognized the need for more scientific knowledge about traffic. Probably all traffic engineers have recognized it and, as their numbers have increased, there has been a corresponding increase in the volume of published research reports.

At present, the Highway Research Board's Traffic and Operations Department has nine project committees studying various problems in connection with parking, origin-and-destination surveys, the influence of shoulders on traffic operation, highway capacity, uses of highway planning data, the effect of limited access expressways on existing street systems, transit, and vehicle characteristics. Other departments find themselves involved indirectly in traffic problems.

Agencies Engaged in Traffic Research

Members of these departments and committees represent the many agencies by which actual investigations are made. One of these is the U. S. Public Roads Administration that probably at all times has a number of its engineers working on traffic investigations. PRA also engages in joint research projects with such other agencies as state highway departments and educational institutions. One of the educational institutions is Iowa State College. The Eno Foundation and Yale University publish valuable reports of traffic research. The American Automobile Association, the Automotive Safety Foundation, the National Safety Council and the National Conservation Bureau are all responsible, directly or indirectly, for many traffic engineering studies.

Because of funds made available to it for traffic activities, Yale University has been able to conduct more traffic research than any

other educational institution. There are several members on its traffic engineering staff while no other university or college, so far as known to the writer, has even one faculty member devoting his entire time to that subject. There are institutions, however, where important traffic research has been conducted. Among them are the Massachusetts Institute of Technology, New York University, and the Universities of Michigan, Illinois and Tennessee. The number is increasing and about a million dollars has recently been appropriated for the establishment of an institute of transportation engineering at the University of California which may become one of the outstanding leaders of the country in traffic engineering research, provided this is to be one of their activities. Detailed plans as to that, if they have been made, have apparently not had wide publicity up to the time this was written.

Future Research Needs

Considering the research already completed, and all that is now planned or in progress, it might be concluded that the subject is well covered without further expansion. The fact is, however, that the need for traffic engineering investigations is not nearly satisfied; it probably never will be. Many elementary, everyday problems still have to be solved on the basis of the traffic engineer's judgment, which is apt to mean, in reality, his best guess in the absence of definite information.

Who knows, for instance, the exact circumstances in which various traffic control devices, or combinations of devices, are justified; if we did know the minimum traffic volume warranting the installation of a fixed-time stop-and-go signal at the intersection of two four-lane streets in a business district, then what about wider or narrower streets, or various combinations of wide and narrow streets? How should the various warrants be changed, if at all, for residence districts of various characteristics? What about intersections of rural highways carrying high-speed traffic, should the warrants be lower? If so, how much lower under the various conditions and circumstances?

How, if at all, would the purpose of the signal, as part of a con-

nected system, affect the minimum-volume warrants under each of the above conditions? Under just what circumstances is the added cost of traffic-actuated, or traffic-density-actuated, signals justified? How should all the fixed-time signal warrants be modified if traffic-actuated signals are used? What effect, if any, would marking traffic lanes near the intersections have on warrants found for unmarked intersections?

What are the corresponding warrants for two-way stop signs, four-way stop signs, stop signs on one street and slow signs on the other? Under what circumstances, if any, should slow signs be marked with a stated speed? If used, how should the stated speeds be determined? Under what conditions should traffic volumes be ignored in placing signals and stop signs? Under what conditions are flashing signals sufficiently effective to be justified?

All of these questions refer to one of the most frequent of all traffic engineering duties, the protection of intersections. Yet it is doubtful if the most experienced traffic engineers could give positive answers to even a few of them. All will admit that the general figures given in manuals are arbitrary to a large extent and are usually determined by mutual agreement among committee members rather than as a result of extensive and detailed research.

Similar lists of questions, the answers to which are unknown, could be made in regard to other simple and common traffic activities such as street-marking, provisions for parking, pedestrian protection and railroad-crossing protection. When one considers such matters as the design of arterial street systems, expressways, and provisions for moving masses of people by buses, street cars or rapid transit, the list of unknowns is even greater and the need for research is correspondingly greater, partly because the cost of mistakes is apt to be enormous.

Finding definite and correct answers to all the present questions would take years of study by many investigators and by the time all the answers were found, there would probably be quite as many new questions needing answers.

At first thought, the cost of this research seems prohibitive. But that is the way successful commercial corporations solve their problems, and people who would pay for traffic engineering research are

really the ones who pay for commercial research, because corporation expenditures must be paid eventually by customers if the company is to remain solvent. Taxpayers, since they include practically everyone, must pay for all goods and services, whether publicly or privately supplied, and that includes practically all research, both public and commercial.

Educating the Public

Probably the greatest problem in connection with traffic engineering research is to convince the public, including officials, that more and more research is needed, that the returns are greater than the costs, and that all the information developed in that way should be *used* in solving traffic problems. The practice of making important decisions, affecting the lives of people, upon the basis of the uninformed opinions of Tom, Dick and Harry, who happen to be public officials or influential citizens, is little short of tragedy. And yet it is continually happening, even where there are good traffic engineering organizations.

Perhaps as long as elected officials have the power to overrule the engineers on technical matters, and as long as votes can be obtained by doing so, there is little hope for great improvement. But laymen, officials or others, do not attempt to tell surgeons in public hospitals how to perform operations; nor do city councils determine, by majority vote, what the treatments shall be for diseases.

The only difference between the attitude toward medical problems and toward traffic problems is a matter of education. For centuries it has been generally realized that dealing with human ailments requires specialized knowledge. Yet there still is no such appreciation as to similar requirements for handling traffic ailments. Public officials are usually intelligent, well-meaning persons who would not *knowingly* sacrifice the lives, limbs, property or even the maximum convenience, of citizens for the sake of a few votes.

The most important research problem now confronting traffic engineers would seem, therefore, to be the problem of determining the most effective methods of educating the public as to the need for technical information in solving traffic difficulties. The first part of

the project might well be a study of the best ways of gaining the support of newspapers. Definite facts must be available for this, and a continual supply of newly discovered facts must be obtained to give to the public.

In other words, traffic engineering research is needed, among other reasons, to convince citizens that they should support more research, and that the results of scientific investigations, rather than unsupported opinions, should be the basis for decisions in traffic matters.

Two-Way, Non-Stop Cross-Traffic Is Proposed for Cities

PIERRE ZANNETTOS

Mr. Zannettos is an architect and civil engineer who lived in Athens, Greece, until the close of World War II. He was graduated in 1933 from the Ecole Centrale des Arts et Manufactures de Paris. He also attended the architectural section of the Ecole des Beaux Arts. He is now a resident of New York, N.Y.

Various phases of systems described in the following article are covered by pending patent applications of the author and by one or more existing United States Patents.

THE enormous waste of time, money and material caused by traffic lights is incalculable. In this country, where much harder scientific problems are solved one after another, it seems illogical that millions of people, all day long, should be obliged to lose time and wear out cars by stopping continually at intersections.

Something could and should be done; something basically and completely new, because it is no longer possible to bring serious improvement to the traffic situation by merely altering details or reinforcing regulations. Such devices, like the parking ban in midtown New York, are anodynes to keep the patient quiet, not to cure him.

No traffic system is perfect. In examining a new system, the important thing is to become thoroughly accustomed to it, and then to judge whether advantages balance favorably with disadvantages or not.

In order to avoid mathematics and to make everything tangible for the reader, I shall discuss in detail a solution for Midtown Manhattan, New York, instead of explaining the process theoretically. Further, I shall give general outlines of other solutions completely different. In this way, the reader can sense the potentiality of the process.

PROGRESSIVE SYSTEM

Let us consider a one-way road crossed at equal distances of 260 feet by perpendicular streets. Suppose that while driving along this highway we see a red light in front of us every four blocks. We see three green, one red; three green, one red; etc. Let us suppose also that every 7½ seconds all the red lights change at the same time, each one moving to the next block ahead. Any car between two consecutive red lights, covering the distance between two consecutive intersections in 7½ seconds—that is, moving at 23.63 mph—is able to cover the whole length of the highway without stopping at any intersection. This is a "progressive system."

The progressive system is not as rigid as may seem. While the red lights move ahead, a car can run at a lower speed than 23⅔ mph. It can even stop if a pedestrian appears, or if a cab in front picks up a passenger. As long as the car is free before the red light behind it jumps to the intersection ahead, this car can run again at 23⅔ mph, or at a higher speed, reaching gradually the last-in-line car in front of it. Even a driver moving steadily at only 20 mph would cross 15 intersections before being caught by the light. But how many would do that when it is so easy and so natural to speed up a little and reach the last-in-line car ahead?

Some criticize the progressive system because the contrary often happens: cars move too fast, reach the red light too soon and have to stop. This is true, but it is the fault neither of the system nor of the drivers. Three factors prevent drivers from conforming to the system:

1. As the progressive system is set up in but few and scattered spots, many drivers do not know of its existence, or are not accustomed to it. When they get into a progressive system they hurry as far as possible, as in the case of the usual system, and then are stopped; or, getting out of the usual system into a progressive one without warning, they use it wrongly until they understand it is progressive.

2. Many times the speed of the system seems low, and drivers are annoyed. They prefer to go faster and stop at the red light. The

setting of too-low a progression speed is a great mistake. It does not prevent speeding, and it disrupts the system.

3. Often, for various reasons, drivers cannot see more than one light at a time. This is bad because they do not know how far away the next red light is and they hurry to catch the next light.

Progressive systems would work perfectly if:

1. They were widely spread.

2. The velocity of the progression on a given highway were as close as possible to drivers' normal average velocity on this highway.

3. Drivers were always able to see the progressing red light ahead or to know at all times their own position in relation to the next red light. Under these conditions, they would neither let it progress faster than themselves—since they would know the coming red light would finally jump over them to the first intersection—nor would they drive too fast, as it would be useless to reach the pilot-light and stop.

Drivers would always know their own position in relation to the pilot-lights and would adjust their speed without any effort, if each signal bore some auxiliary green traffic lights. These would show, by the number of them lit, how many blocks ahead the first red light would be.

Main green alone	would mean: Red light one block ahead
Main green and 1 auxiliary green	would mean: Red light two blocks ahead
Main green and 2 auxiliary green and so on	would mean: Red light three blocks ahead

Under those circumstances, drivers would automatically adjust their velocity to the right level and, with the flexibility of the system, it would seldom be necessary for them to stop.

DENSITY AND SPEED

For a given traffic volume (V) the density (D) of the cars, quantity of cars per unit of street-surface at a given instant, is inversely proportional to their average speed (S), at least for the usual speeds

$$D \cdot S = kV = K$$

If S rises to $S' = 2S$, D drops to $D' = \frac{D}{2}$, as long, however, as S' is compatible with D'.

Let us consider a two-lane one-way highway one mile long; a steady traffic volume of 10 cars a minute, an average velocity $S = 10$ mph. A car covers the mile in six minutes and at any time we have $10 \cdot 6 = 60$ cars spread along the two lanes; $D = 60$.

Let us suppose now that S rises to $S' = 20$ mph. The cars cover the mile in three minutes each, and as they still enter the mile at a rate of ten per minute, at any time we have $10 \cdot 3 = 30$ cars on the two lanes: $D' = 30 = \frac{D}{2}$.

Let us examine it more thoroughly and suppose that several lights are set along this mile; the ten mph average-velocity implies that the cars run, for example, at a double velocity; the density D, therefore, is compatible with a "True-Speed" of 20 mph and not merely with 10 mph.

If we set up a progressive system on this highway, based on a velocity of 20 mph, we would have two alternatives:

1. To use the two lanes and have the density D drop to $D' = \frac{D}{2}$

2. To use one lane, thus doubling the density D' that we had for two lanes, the new density for one lane being $D'' = 2D' = \frac{2D}{2} = D$ and the average velocity being 20 mph.

D and 20 mph are the conditions we had while cars were moving between two stops with the usual system; they result from the free combination of all intervening factors and are compatible with each other.

Conclusion:

1. With the progressive system, we save one lane and we double the average velocity, everything else being as if we had an ever-green light with the usual system.

2. The right velocity of a progressive system is the "True-Speed" of the cars while moving from one stop to the next stop in the usual system. This is true as long as two consecutive stops are far enough

from each other to permit cars to reach the highest velocity compatible with their number.

TWO-WAY, NON-STOP CROSS-TRAFFIC

East Side Manhattan

Let us consider a one-way progressive system—one red light, three green, one red, three green, and so on—set up on all the avenues; all

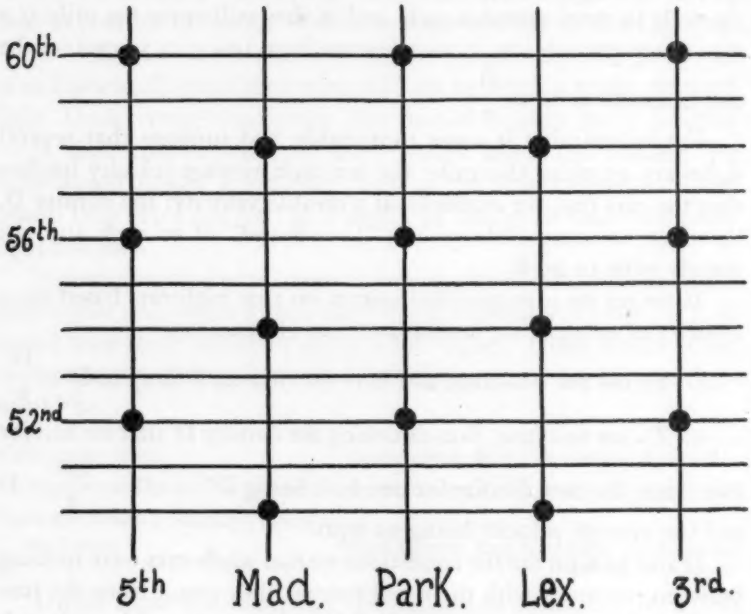


FIG. 1. Nucleus position.

the red lights moving at the same time, each one to the next block ahead, every 7½ seconds.

Suppose that when we start the system at the time zero, all progressive systems on the avenues of odd-rank occupy exactly the same position: if we have a red light on Third Avenue at 60th Street, we also have a red light on Park Avenue, the fifth in rank, and on Fifth Avenue, the seventh in rank, at 60th Street.

Suppose also that progressive systems on all the avenues of even-

rank, like those of odd-rank, occupy at the time zero exactly the same position, all their red lights being at the corners of the same streets.

Finally, let us suppose that if the systems of odd ranks have their red lights at 60th, 56th, 52nd, 48th Streets at the time zero, at the same time, the systems of even-ranks have their red lights at 58th, 54th, 50th, 46th Streets. In Figure 1, the circles show the red lights on the avenues; it is understood that other lights on the avenues are green, and that the light on any crossing street has the contrary color of that shown on the avenue, at the intersection.

Let us designate by Nucleus Position the position occupied by the lights in Figure 1; by Nucleus Lights the red lights; and by Nucleus System any combination of progressive systems, the red lights of which occupy periodically a Nucleus Position.

Under these conditions, we have not only one-way, non-stop traffic on the avenues, but at the same time, we have two-way, non-stop traffic along the streets; and these two traffics, N-S and E-W, cross each other without interfering.

We know that the traffic is non-stop on the avenues. We have only to prove that a car running E-W or W-E can cross all the avenues without making a stop.

Let us consider on 56th Street a car reaching and crossing Fifth Avenue eastward, exactly at the time zero, when the light turns red on Fifth Avenue, Figure 2. Let us suppose that this car needs fifteen seconds to reach the next intersection with Madison Avenue at the time $+15$. At that time, the red lights of Madison Avenue have moved $15 \div 7 \cdot 5 = 2$ blocks ahead; the red light, which was at 54th Street or 58th Street, has just moved to the intersection of 56th Street and stays there for $7\frac{1}{2}$ seconds.

In the figure it is the light at 54th Street which comes to 56th Street. Our car reaches Madison Avenue just in time, crosses it and progresses toward Park Avenue, the next avenue. I shall explain further how to increase the time $7\frac{1}{2}$ seconds, which is too short. If the length of the block is 500 feet, the velocity of the car must be 22.73 mph, roughly $22\frac{3}{4}$ mph.

If all the blocks are the same length, the car reaches Park Avenue fifteen seconds later, at the time $+30$. But, again, by this time the red lights on Park Avenue have moved $30 \div 7 \cdot 5 = 4$ blocks ahead since

the time zero. The red light which was at 52nd or at 60th Street has just lit at 56th Street and stays there for 7½ seconds. Again the car reaches Park Avenue just in time, crosses and progresses toward the fourth avenue or Lexington Avenue, and so on, because the Nucleus Position is symmetrical and the lights on Park Avenue occupy, in relation to the other avenues, exactly the same position as the lights on Fifth Avenue. Let us remark that the above is completely independent of the direction of the one-way traffic on each avenue.

It is easy to see, in the same way, that a car crossing Third Avenue westward on 56th Street, at the time zero or at any time multiple of thirty seconds, and reaching every next intersection fifteen seconds after it has crossed the last intersection, always meets a green light (red on the avenue) and crosses all the avenues without making any stops. Fifty-sixth Street has two-way non-stop traffic.

The same procedure for a car crossing Third Avenue westward or Fifth Avenue eastward on 55th Street would show that on 55th Street the car must move at half the velocity it moved at on 56th Street, while on 54th Street it should run again at the same speed as on 56th Street.

Let us designate by "Synchronization-Speed" the speed which the cars must keep in order to reach the next intersection in time.

Conclusion.

1. We have one-way, non-stop traffic on the avenues while, at the same time, we have two-way non-stop traffic along the streets.

2. The streets are divided in two series that we designate by "Cross-Drives" and "Common Streets." The first series corresponds to a Synchronization-Speed double that of the other.

In the case of Manhattan, it happens that the last two blocks between Third and First Avenues are about 40 per cent longer than the other blocks. I shall explain, at the end of this study under the title "Dissymetrical Cities" how we can re-establish the symmetry and include these blocks in the net.

Two-Way, Non-stop Traffic on Avenues

Suppose, now, that we make two identical progressive systems move in contrary directions along each side of an avenue, as if each side

were an independent one-way avenue. If the red lights of these two systems are lit at the corner of the same Cross-Drives at the time zero, we still have two-way non-stop traffic on the Cross-Drives but no longer along the Common-Streets.

It is clear, in Figure 3, showing the position of the lights on this avenue at the times 0, +7½, +15, +22½, +30 or 0, that the coincidence of the red lights at the same intersection occurs only and

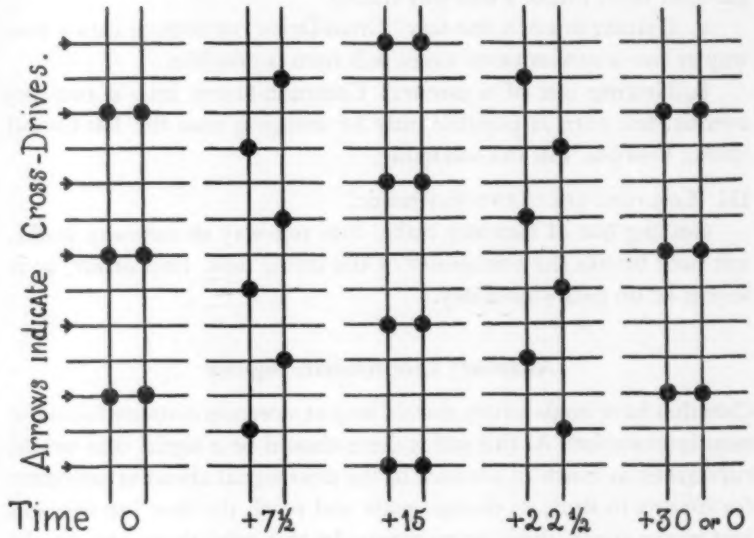


FIG. 3. Two-way non-stop traffic on an avenue—complete cycle.

always on the Cross-Drives. At the intersections with the Common-Streets we have one red light of the first progressive system and, at the same time, one green light of the second system, or two green lights; it is impossible to cross two-way avenues through Common-Streets. At the end of the block of a Common-Street the light should be always red and, when it is time for a green light, only a green arrow should appear for a right or a left turn.

We have reached two-way non-stop traffic on the avenues, but we have lost the non-stop traffic along the Common-Streets; as we shall see, this is not important.

It is not necessary to have different signals for each progressive system of lights. We can use all the faces looking in one direction for the first system, and all the faces looking in the second direction for the second system.

Turns

I. Right turn: Always possible

II. Left turn, out of a one-way traffic:

a. Getting out of a one-way "Cross-Drive" or avenue into a one-way or two-way avenue or street, left turn is possible.

b. Getting out of a one-way Common-Street into a two-way avenue, left turn is possible only by merging into the left-bound traffic. Possible, but not advisable.

III. Left turn out of two-way traffic:

Getting out of two-way traffic into one-way or two-way traffic, left turn breaks the continuity of the traffic flow. Impossible, as it would be on parkways today.

Auxiliary Intermediate Signals

Cars that have made a turn should stop at a certain distance from the next intersection. At this point there should be a signal that would turn green as much in advance of the next signal ahead as necessary for drivers to start, to change gears and reach the first intersection just as the signal there turns green. In this way, these cars would cause no delay or perturbation. They would be in motion by the time coming cars reached them, a little before the intersection.

The same signal should turn red as much in advance of the next signal ahead as necessary for a car, which had passed this signal on green, to be sure to have time to cross the next intersection. This would avoid the stopping of cars at the intersection, which would disturb traffic when the cars started.

A DRIFTED SYSTEM FROM NUCLEUS SYSTEM

Let us consider a Nucleus System combined with a second system identical to the Nucleus System, but the lights of which occupy at

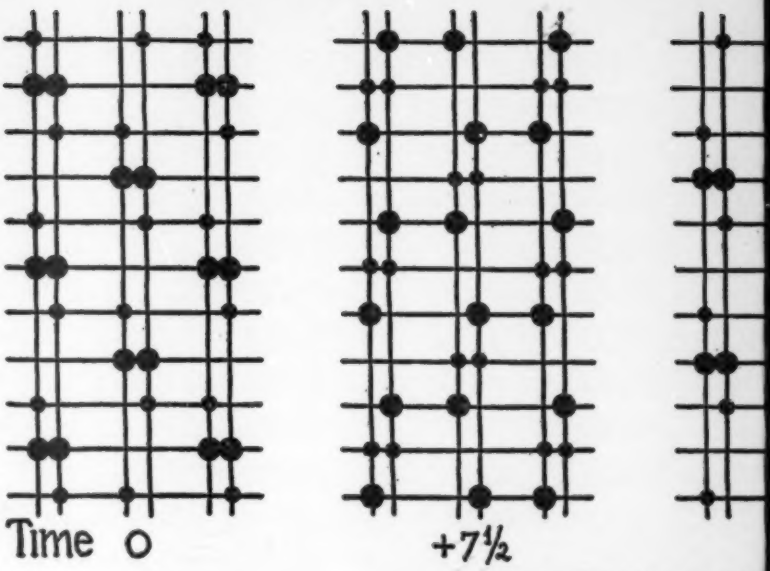


FIG. 2. A car running at 23 and two-thi

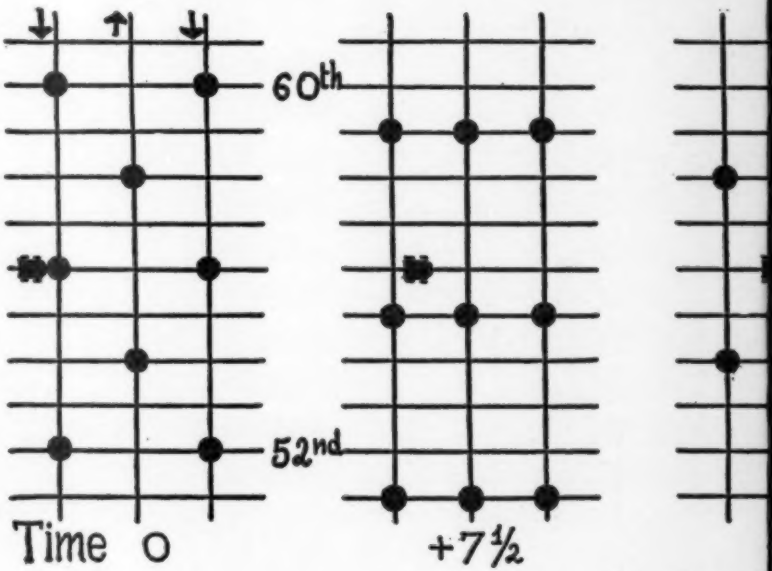
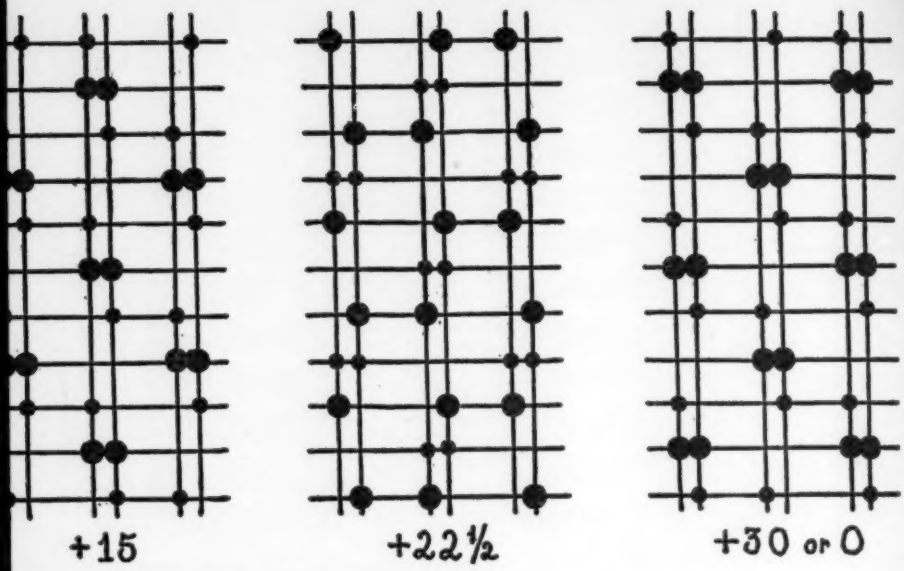
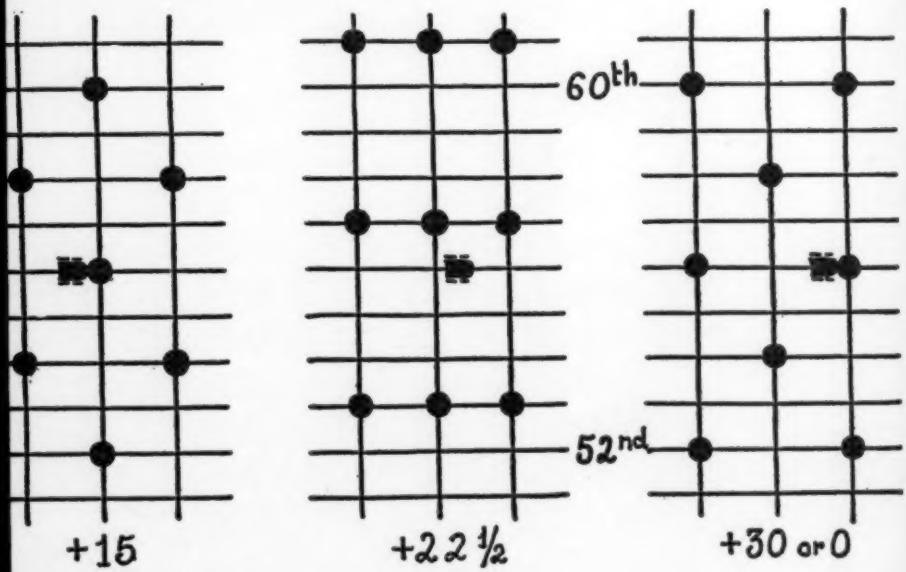


FIG. 5. Timing dia



wo-thirds MPH crosses all the avenues without stopping.



ing diagram for the drifted system.

the time +30, the position which lights of the Nucleus System occupied at the time +22½. This is done simply by adding one red light next to, and back of, every Nucleus Light. In Figure 4, the Nucleus Lights are shown by a black circle, and the added lights by a smaller circle. The avenues are two-way. The combination of the two systems, or *drifted system* by juxtaposition, improves considerably the Nucleus System.

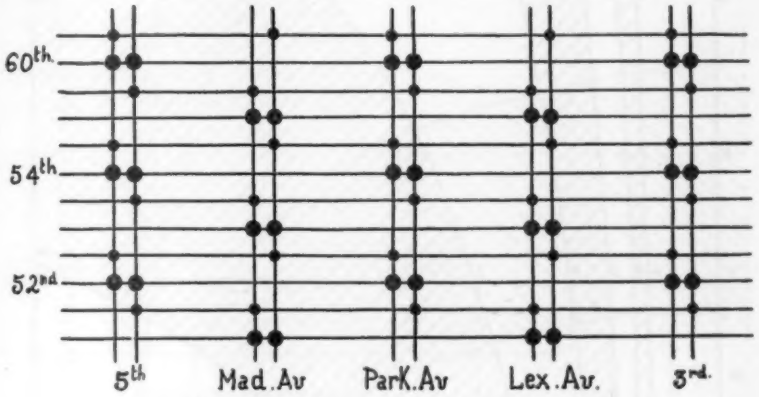


FIG. 4. Two-way traffic–drifted system by juxtaposition.

Crossing Time

The time given cars for crossing the avenues, or "Crossing-Time," is double in the drifted system (fifteen seconds), since, next to the Nucleus Light, which stays on for 7½ seconds, comes another red light which also stays on for 7½ seconds. Every light stays red for fifteen seconds, while every 7½ seconds, each red light moves to the next block ahead.

Flexibility

The drifted system is unexpectedly flexible.

Since lights on the avenues are red for fifteen seconds, a car crossing one avenue along a Cross-Drive, Figure 5, at the time zero, and reaching the next intersection at not exactly the time +15, but between the times +15 and +30, may still cross without stopping. Its

average speed can vary between 22¾ and 11.38 mph. The same car, reaching the next intersection one cycle later, at the time +45 or between +45 and +60, again finds the way open and crosses without stopping. Its average speed can vary between 7.58 and 5.69 mph. In the same way, for the next cycle, its average speed can vary between 4.55 and 3.79 mph and so on.

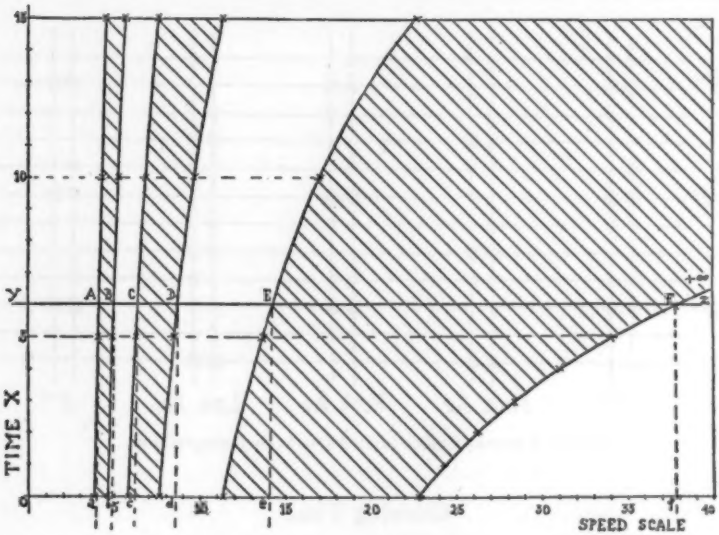


FIG. 6. Synchronization speed areas for street-traffic.

If we make the same calculations for a car crossing the first intersection at the time X = +1, or +2, or +3, or +14, instead of the time zero, and reaching the next intersection during the same cycle, or during the second, or third one and so on, we find for each time and for each cycle two new values for the maximum and the minimum of its average speed.

For each cycle we can draw two curves representing the maximum and the minimum of the average speed in function of the time X: horizontally, we have the velocity, and vertically the times X, Figure 6. The area between these two curves is a synchronization-speed area. Once we fix the time X, we draw a horizontal line YZ at

the level of this time, +6, for example, and from the intersections A-B-C-D-E-F of this line with the curves limiting the synchronization-speed areas, we draw vertical lines downward intersecting the scale of the velocities at a-b-c-d-e-f.

All speeds between (a-b), (c-d), and (e-f) are possible synchronization speeds for a car crossing the first intersection at the time +6.

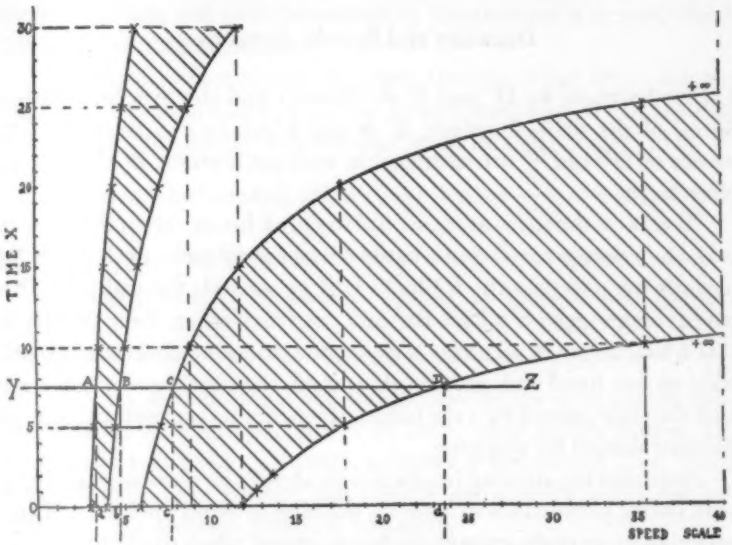


FIG. 7. Synchronization speed areas for avenue traffic.

Contrary to what one might think, the difference between the maximum and the minimum of the speed, for a given cycle, increases with the time X. It is greater for a car crossing at +10 than for a car crossing at +5.

On the avenues, we have something similar. Consider a car crossing an intersection at the time +X, and suppose that the next intersection is open from +15 to +30 and from +45 to +60. If the car reaches the next intersection between the times +15 and +30, or one cycle later, between +45 and +60, it finds the way open and crosses without stopping. For each cycle we can draw two curves, one for the maximum and one for the minimum value of the average

speed in function of the time X, Figure 7. The areas between these two curves are synchronization-speed areas; we use them as in Figure 6.

These large Synchronization Speed Areas show that, with the help of the pilot-lights, the drivers could and would readjust their speed almost unconsciously.

Densities and Speeds: Avenues

Let us designate by D″ and S″ the density and the Synchronization Speed of the drifted system; S″ is one block in 7½ seconds. The values of D″ and S″ are compatible with each other, in the case of New York:

Today on the main avenues, during peak hours, when the density is D, the average speed S of a car is 6 blocks per 90 seconds cycle, 55 seconds for covering the 6 blocks and 35 seconds for waiting. The true average speed S′ which the cars can reach when their density is D is 6 blocks per X seconds, X being the difference between 55 seconds on one hand and, on the other hand, the starting reaction time plus the time wasted by a car before it reaches its normal speed, plus the time wasted for stopping.

Note that the starting reaction time should be increased, since, at peak hours, pedestrians in a hurry, wanting to avoid the long waiting period of 55 seconds, cross at the last moment, when the light has just changed. We must reduce 55 to at least 45 seconds, the True-Speed S′, compatible with D, being equal to 6 blocks per 45 seconds, which is the double of S. But $S' = 2S$ is also equal to S″ as 6 blocks per 45 seconds is one block in 7½ seconds; therefore, S″ is also compatible with D.

Let us see now that $D'' = D$ and that, therefore, S″ is compatible with D″; since our drifted system progresses at the speed $S'' = S' = 2S$, its density should drop to $D' = \frac{D}{2}$, but the fact that we have alternately two green and two red lights on the avenues prevents the cars from spreading over more than two blocks out of four and the density rises again to $D'' = 2D' = \frac{2D}{2} = D$.

Conclusion:

1. As $S' = S''$, D compatible with S' is also compatible with S''
2. $D'' = D$
3. As $D'' = D$, S'', compatible with D, is also compatible with D''.

The drifted system works under the same conditions of speed and density as the usual system during the green period, but the average speed is double and half the surface of the avenues is empty, which lets the cross-traffic through.

The above does not mean or prove that the value $D'' = D$ is the highest value compatible with the True-Speed $S' = S''$. In the case of New York the density can increase by more than 50 per cent:

Today, on the avenues, the way is open for $\frac{61}{100}$ of the cycle and closed for $\frac{39}{100}$, the times being 55 seconds and 35 seconds.

Suppose that still using today's system, we increase the length of the cycle so that the 55 seconds of green on the avenues be the $\frac{39}{100}$ of a new 141 seconds cycle. We would have on the avenues the same proportions for green and red as we have today on the streets. The cars would still have 55 seconds to cover 6 blocks and their True-Speed S' would not change, but the average speed would drop to 6 blocks in 141 seconds, which is $7\frac{1}{2}$ mph.

If we suppose that we can still carry the same traffic volume per hour although the way is open only $\frac{39}{100}$ of an hour, instead of $\frac{61}{100}$ then we must admit that the density has increased to:

$$D''' = D \cdot \frac{\text{Average speed today}}{\text{New Average speed}} = D \cdot \frac{11.83}{7.5} = 1.58D$$

and that D''' is still compatible with the True-Speed S' of today, because if it were not, the average speed would drop lower than $7\frac{1}{2}$, to 6 or 5 mph.

But according to the police traffic survey report of September 1940, the traffic volume per lane of a few streets is the same as the traffic volume per lane on the main avenues; if we add to this that

the average speed on these streets is 7 mph, we see that the preceding SUPPOSED conditions for the avenues are exactly the conditions which we have today on these streets; same volume as avenues, same proportion of green per cycle and same average speed, 7 mph. Therefore, these conditions are possible and the density $D''' = 1.58D$ is compatible with the True-Speed $S' = 23\frac{3}{8}$ mph.

The preceding proves:

1st. Since the density on the avenues has not yet reached its maximum value compatible with the True-Speed S', there is more than 50 per cent margin for increase in the traffic volume in the future.

2nd. The True-Speed, in the worst conditions of crosstown traffic, can be equal to $23\frac{3}{8}$ mph and normally much higher.

Densities and Speeds: Streets

On most of the *streets,* the True-Speed could be much higher than $23\frac{3}{8}$ mph but it is difficult to estimate it exactly because the blocks are too short. Furthermore, as the first-in-line driver knows he has to wait at the next intersection, he does not reach, by far, the highest speed compatible with the density of the cars. Let us adopt $22\frac{3}{4}$ mph, which we chose at the beginning of the study. Under those conditions it would be possible to carry, with a large margin to spare, all of the crosstown traffic through the Cross-Drives alone and close completely the Common-Streets.

Since the True-Speed $22\frac{3}{4}$ mph is at least three times higher than the average speed 7 mph, we need use only one street out of three, and still have the same density as today, compatible with the True-Speed or speed of the drifted system. In fact, we use one street out of two, which is more, and the density drops considerably:

$$D' = 2D \cdot \frac{7}{22\frac{3}{4}} = 0.61D$$

Conclusion:

We could carry the whole crosstown traffic through the Cross-Drives alone with such a large margin to spare that the traffic volume could increase 60 per cent before we reached today's density. But if we increased by that much the number of cars, one might ask the

question: Is it possible to make all these cars cross an avenue with a fifty-fifty cycle?

Highest Volume

Let us suppose that today V is the highest traffic volume carried per hour through two lanes of a single street. Street-traffic has the way open only during $\frac{35}{90}$ or $23\frac{1}{3}$ minutes per hour. If we take into consideration that each time the way is open for street-traffic it is for only 35 seconds, when the traffic is supposed to be heaviest, that cars reaching an intersection seldom find the way open, that therefore a lot of time is wasted in reaction times, we must consider that the average speed of the cars, at the time they cross the intersection, is not higher than 13 to 15 mph.

Under these conditions, if we carry the volume V in $23\frac{1}{3}$ minutes, in half an hour we could carry $V_1 = \frac{30V}{23\frac{1}{3}}$ and if the speed rose from 14 to $22\frac{3}{4}$ mph, we could carry the volume:

$$V' = \frac{30}{23\frac{1}{3}} \cdot \frac{22\frac{3}{4}}{14} V = 2.08V$$

The above proves that the drifted system, which works under the same conditions, way open half an hour per hour and speed of $22\frac{3}{4}$ mph, is able to carry across the avenues a volume V′ double the heaviest volume V carried today or in the future, in the usual system.

Even if each street carried a traffic volume V equal to the highest volume carried through only a few streets today, and if we used one street out of two, we still would be able to carry the entire crosstown traffic through the Cross-Drives only. We see that here, too, the system leaves a large margin for future increases.

Parking

As all street-traffic is so easily carried through half the existing streets, the Cross-Drives, we can organize oblique parking on a large scale in the Common-Streets; theoretically 50,000 cars in midtown Manhat-

tan alone, but in fact less, as selected spots should be kept free for loading, unloading or deliveries.

Since we would give everyone the right to park in every other block, parking on avenues and Cross-Drives should be ABSOLUTELY forbidden. Cabs should be obliged, under penalty of law, to enter a Parking-Street before dropping a passenger or picking him up; the same should be valid for private cars driven by chauffeurs. These measures and similar, although not necessary for the good working of the system, as we saw above, would in fact considerably ease and smooth the traffic flow and secure even more margin for future increases. I repeat that these measures are perfectly workable, since everybody can park or stop in every other block.

In order to avoid useless parking, only the two first hours would be free, the parking fee for each succeeding hour being higher than for the preceding hour. In this way, opportunity would be given to people who really need it to park a longer time, but they would think it over before parking uselessly as the fee would increase rapidly from one hour to the next—fees collected by parking meters.

Broadway

Broadway, the only oblique avenue in Midtown, cannot be incorporated in our net of avenues and Cross-Drives. Broadway becomes a vast parking space all along the heart of the city, its traffic volume is easily absorbed by the other avenues which, in our system, as we saw previously, can increase their volume by 50 per cent.

Pedestrians

Pedestrian traffic would be under the following conditions:

1. If X pedestrians cross at each time today, with the non-stop system they would be $\frac{X}{3}$ as their way would be open 120 times an hour instead of 40.

2. The space pedestrians could use for crossing would be practically unlimited because at the time of crossing, the nearest approaching

car would be one street-block or two avenue-blocks away. Pedestrians could spread themselves along a double length front, two widths of an avenue or of a street sidewalk, for example. Conditions would be as if pedestrians were half as numerous: not even $\frac{X}{3}$ but $\frac{X}{6}$. Pedestrians would have priority over turning cars.

For those reasons, pedestrians would have neither to crowd themselves in rows nor fight their way among cars which stopped too far onto their crossing zone.

Like the cars, pedestrians crossing a two-way avenue along a street could not cross at parking-street intersections. They should use only Cross-Drive intersections where they would be $2\frac{X}{3}$. But because they would spread themselves along a double or triple front, conditions would be as if the pedestrians were only $\frac{X}{3}$ or $\frac{2X}{9}$.

An objection to that is that in some places in New York, where the avenues are especially wide, 15 seconds is not enough time to cross. This is right, but since conditions would be as if pedestrians were 3 or 6 times less numerous than today, we could place long, narrow islands in the middle of the avenues, at equal distances from the sidewalks, as on Michigan Boulevard in Chicago. These pedestrian shelters would cut in half the distance to cross in 15 seconds and would permit the use of Parking-Street intersections in the case of a two-way avenue.

Even so, pedestrians missing the light would require a shorter time than today to cross the avenue. If "t" is the time necessary to cross an avenue, the total time needed is 15 seconds waiting on the sidewalk plus $\frac{t}{2}$ crossing the first half of the avenue, plus 15 seconds waiting on the shelter plus $\frac{t}{2}$ crossing the second half of the avenue; total 30" plus t. Today this time is 55 seconds plus t; that is, 25 seconds more, which is worse.

With the non-stop system, pedestrians' crossing would be faster, easier and safer.

Clearance Interval

There are two ways of realizing the clearance interval: the signals are never red for both directions at the same time; or, on the contrary, there is a *short period,* "t", during which the signals *are* red for both directions.

In the first case, there is nothing to change to our timing; we must divide the green period in "green" and "finishing green," finishing green being "green and yellow" or "yellow" or "no light at all."

In the second case, each time a light turns red, the light of the other direction turns green "t" seconds later; the consequence is that in this direction the crossing time is "t" seconds shorter. In practice it does not seem of any use to adopt this kind of clearance as drivers always use these "t" seconds of red as green, whether crossing last-in-line or starting first-in-line.

MIDTOWN MANHATTAN WEST SIDE

We have not yet spoken of the West Side where the blocks are about 10 per cent shorter than four blocks on the avenues.

On the map of the West Side, let us add virtual avenues exactly in the middle between two consecutive real avenues. The new blocks formed by real and virtual avenues are about 10 per cent shorter than two blocks on the avenues.

Let us use on these avenues the same progressive systems we used in the East, as if the West Side, with the virtual avenues, were the prolongation of the East Side; and let us draw a Nucleus Position for these twin Nucleus Systems.

Same reasoning as for the East Side would show that a car running at 23⅜ mph less 10 per cent, which is about 21¼ mph, reaches every intersection, real or virtual, exactly when the light turns red on the avenue and crosses all the West Side without stopping anywhere. In practice, we cancel the virtual avenues and our East Side system is absolutely synchronized with our West Side system, the progressive systems being the same for all avenues.

Truck Area

A large area of the West Side is designated as the Truck Area. Huge trucks load and unload there all day. Traffic reaches the top jam because of the following two reasons:

1. The trucks leave one lane only free between their two long lines.

2. The slow one-lane traffic, which should have the way open for as long as possible, is constantly stopped by the red light, and has to wait $\frac{61}{100}$ of an hour *per hour*.

The first cause cannot be avoided. The trucks are a fact. But the second is almost totally eliminated with non-stop traffic. Synchronization speed areas show that in any circumstances a car in this one-lane traffic, progressing at a low average speed, would seldom have to wait. We effect the only change logical: we make the traffic go-through continuously; slowly, but *continuously through*, instead of trapping it.

IN SHORT

The chosen drifted system is characterized by:

1. One or two-way non-stop traffic on avenues and streets.
2. Average speeds double, triple or more.
3. Large flexibility shown by Synchronization Speed Areas and secured by judicious speeds and pilot-lights.
4. Large margins for traffic volume increases in the future.
5. Parking problem solved at practically no cost.
6. Pedestrians' crossing faster, easier and safer.
7. Truck area's problem solved in the best possible way.

Whatever is, and will be, the traffic volume carried by the system in use today, the drifted system carries, and will carry it with much more efficiency.

FOUR OTHER SOLUTIONS

If we had chosen a Nucleus System built on a progressive system with one red light followed by five green lights instead of three, we

could have drifted two other systems by adding back of and next to the Nucleus Lights one or two red lights. In each case we should have had one Cross-Drive every three streets instead of two, and we could have examined all the points of these solutions exactly as we did for the chosen example.

When the number of Common-Streets is greater than the number of Cross-Drives, as above, every Common-Street has two synchronization speeds which alternate along the blocks of odd and even rank. Non-stop traffic along these streets would not be practicable if the difference between these two speeds were important.

The following solutions are proposed for those who want a long cycle. They lie between the system in use today and the 100 per cent non-stop system. They require a one-way traffic and consist of starting from a Nucleus System with one Cross-Drive every three or four streets for example, and then of drifting first a system "by suppression."[1]

1. The progressive systems, drifted by suppression, established on the avenues have one red light followed by eleven green lights. We have one Cross-Drive every three streets. All the red lights move at the same time, each one to the next block ahead every $7\frac{1}{2}$ seconds. The cycle is $7\frac{1}{2} \times 12 = 90$ seconds. Let us add, as we did previously, four red lights back of, and next to, every Nucleus Light. Our new systems have five red lights followed by seven green lights. Every other condition on the avenues is as in the first solution thoroughly examined previously.

Crossing time for street-traffic is $5 \times 7\frac{1}{2} = 37\frac{1}{2}$ seconds out of 90 seconds, instead of 35 seconds today; practically the same.

Conclusion:

Though we do not change the conditions under which local-street-traffic is organized today, we get a non-stop traffic on the avenues at a double-average speed and, at the same time, a series of Cross-Drives, one every three streets, for a non-stop crosstown traffic.

2. In the second case, one Cross-Drive every four streets, we have

[1] Discussed further under sub-title, "Drifted Systems."

one red light followed by 15 green lights and we add six red lights. Conditions on the avenues are exactly the same, but we increase considerably the crossing time for street- traffic, 52½ seconds instead of 35 seconds today. The average speed of the local street-traffic is increased by 50 per cent.

These systems have much greater flexibility.

BASIC EQUATIONS

If we designate by:

1. (b) the length of the blocks from axis to axis along the direction in which they are shorter
2. (t) the time necessary to cover the distance (b)
3. (s) the speed of a car covering the distance (b) in the time (t)
4. (B) the length of the blocks from axis to axis along the direction in which they are longer
5. (T) the time necessary to cover the distance (B)
6. (S) the speed of a car covering the distance (B) in the time (T)
7. (2n) the number of lights, one red (2n–1) green, of the progressive systems which we set along the direction in which the blocks are shorter.

A Nucleus System is completely defined by the Nucleus Position and the three following equations:

$$1.\ b = st$$
$$2.\ nt = T$$
$$3.\ B = ST$$

We have a system of three equations relating the five quantities S-T-s-t-n—b and B being known for a given city. If we choose only two of these quantities, the three others are known and the whole system is defined.

DRIFTED SYSTEMS

Drifted Systems can be obtained not only by juxtaposing red lights next to Nucleus Lights but also by suppressing Nucleus Lights or

intercalating new red lights. Drifted-Systems can also be combined with each other. The right solution of the traffic problem of a city does not depend solely upon the choice of the Nucleus-System, but mainly upon the right Drifted System.

I. By suppression: In many cases, Drifted Systems by suppression are highly useful. Let us suppose that in a Nucleus System we cancel one Nucleus Light out of two, as shown in Figure 8.

1. While we still have the same number of Cross-Drives, the available space between two consecutive red lights on the avenues is

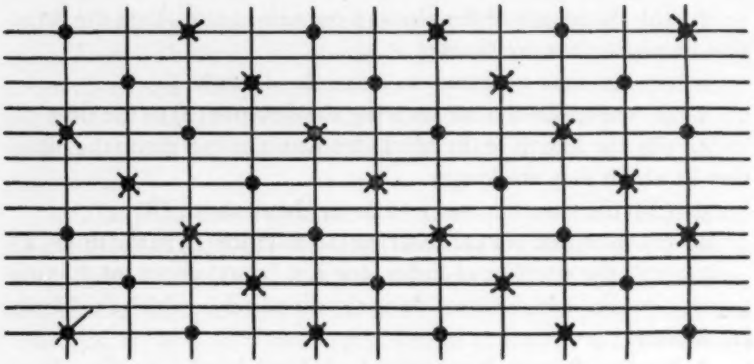


FIG. 8. Drifted system by suppression.

more than doubled. This permits more red lights to be added next to each other, thus increasing the crossing time under better conditions.

2. But the whole traffic has to be alternately one-way down and up for the avenues and the same for the Cross-Drives.

II. By intercalation: Suppose that in a Nucleus System we add red lights between two consecutive Nucleus Lights, but not next to them. If all the added lights occupy the same position in relation to any two consecutive Nucleus Lights, the new system of lights behaves exactly the same as in the Nucleus System. The combination of these two systems is a Drifted System by intercalation.

III. Of course, we can mix all these systems and find that any new combination has its own advantages and disadvantages.

DISSYMETRICAL CITIES

In certain cities, although streets and avenues are parallel in two principal directions, the map is dissymetrical because distances between avenues or between streets are not equal. In this case it is possible to reestablish the symmetry of the map as follows: If the shortest distance between two avenues—either for the city or for a district—is a common divisor or nearly so, of most of the other distances, we may use this number. Or we try a smaller number. Thus we complete the map with *virtual* avenues so that distances between any two consecutive avenues, real or virtual, are equal to the chosen common divisor. We do the same for the streets.

We build a non-stop traffic system on this virtual map. Because the too-long length of certain blocks and their difference from other street-lengths would completely upset drivers who would have nothing to pilot them at the right speed, we set a signal at every *virtual intersection*. The sole purpose of these signals would be to warn drivers that they are driving too fast or too slowly but not to stop them. The signals should show yellow instead of red.

CENTRAL STATION

All the signals of a city should be controlled in a single central station in order to obtain perfect synchronization and to fit the length of the cycle or to change the basic Nucleus System, according to developing traffic conditions. It would take only an hour or two to establish this non-stop system in Chicago, because more than seventy intersections in the Loop are now controlled at a central station.

At first reading, it is hard to visualize the whole picture of this process as it would operate in practice. But, the more skilled one becomes in thinking of pilot-lights, average and true speeds, densities, volumes, crossing-times, nucleus and drifted systems, etc., the more easily one can visualize how smoothly this system would work in practice.

Many new things at first seem impossible. Then they become routine.

Traffic Factors in Bridge Planning

M. EARL CAMPBELL

Mr. Campbell is Engineer of Traffic and Operations for the Highway Research Board, Washington, D. C. Previously he was State Planning Engineer of the State Road Commission of West Virginia. He is a member of the Institute of Traffic Engineers, a member of the West Virginia Society of Professional Engineers, and a Registered Professional Civil and Structural Engineer in West Virginia.

THIRTY-THOUSAND highway bridges need rebuilding or remodeling.[1] This statement may startle some readers because of the immensity of the task. The need is a challenge to the highway department to build today with the accumulated wisdom of the past.

Many of these 30,000 bridges must be rebuilt, not because of decadence, but because of *obsolescence*. Obsolescence is caused by lack of foresight or lack of funds. Newly-weds must often start housekeeping in unsuitable quarters. The most important thing for newly-weds is to make a start that is within their means. Careful planning and financing of the home comes later. It is not for us to criticize the engineers of the 'twenties for today's situation. The important thing in those early years was to "get started."

We recognize that the bridge is a constituent unit of the transport system. Borrowing a term from mathematics we may call it a part of the integrand, a unit of that which is to be integrated into the complete transport system. In the past, instead of seeing highway and bridge "built to each other" we often saw the highway "built to the bridge"—another case of a 4-inch tail wagging a 96-inch dog.

Correlation in Planning

An important purpose of the bridge is to serve traffic safely and expeditiously. To achieve balance in these regards is structural economy. These statements imply a necessity for correlation among location, planning and bridge departments to obtain the proper integration of the bridge unit with the whole system.

[1] AASHO Survey of 1944.

In this article is discussed the influence of traffic on the location of free and toll bridges, and on designs for safe and economic operation of the individual structure. This discussion also points out a way for cooperative effort among departments involved.

Bridges are built (1) to provide an entirely new facility, (2) to replace a facility, or (3) to *relieve* a facility. As the traffic applies to location, it poses a distinct problem in each case. A consideration of each case is therefore essential.

1. As an entirely new facility, a bridge may be built to induce new traffic, or to release traffic that has previously existed as potential or stranded traffic. It is hard to conceive of a community with "absolutely stranded" traffic, yet there are many instances of traffic stranded to a limited extent because of distance to the nearest bridge; or because of the high cost of ferry service, or of a lack or irregularity of an adequately close ferry.

In this case the volume of bridge traffic can be estimated only on the basis of experience with comparable situations where bridges have been built. Induced traffic varies with economic and social environment. Where an entirely new facility is created, adjustments may continue for several years before the full impact of induced traffic is felt.

Investigations being made to establish an empirical formula, or a constant similar to the Newtonian Constant of Gravitation, may provide a solution to the question of induced traffic volume. Not enough experience has been recorded so far to establish a reliable formula. Estimates in this field must be a matter of judgment at this time. As to location, the best procedure is to place the bridge so as to require the least out-of-way travel between gravity centers of the traffic generators. In doing this, the probable changes in population should be considered.

2. When the new bridge is to *replace* a ford, ferry, obsolescent or decadent bridge, the traffic factor can be evaluated without too much difficulty. The administrator knows that the probable use of the new facility will be at least as much as the use of the old facility. Where a bridge is to substitute for a ferry, however, an induced traffic often results from the faster facility. Again, the induced element of traffic must be estimated on the basis of previous experience with

comparable situations, of which there is an increasing amount of fairly reliable data.

Where the facility to be replaced has been in service many years, and established communities exist at each end of the bridge, a replacement at the same relocation may be proper. If there is doubt that this is the proper location, an origin-and-destination survey should be made to determine the desire-line of travel. When a facility is replaced, traffic use of the replacement is almost immediate and complete. Increased use in the future commonly parallels the normal increases elsewhere.

3. In building a bridge to relieve a facility, or divert traffic from bridges with inadequate capacity, location and design are a real problem. Happily, origin-and-destination surveys correlated with time-and-delay studies are a solution. Methods of making these studies will not be discussed, other than to suggest that O and D information may be obtained by *sampling* the traffic that crosses bridges from which traffic will be diverted.

Analyzing Field Data

Different methods have been used for evaluation. Among them are graphical and mathematical analyses.[2] In graphical analysis for urban and suburban locations, the following methods have been employed:

a. *Single centroid*

This procedure brings a quick answer. In it, the centroid of all origins and destinations is calculated. But the centroid may not fall at the river to be crossed. So the sphere of influence of the proposed bridge must be arbitrarily established before calculating the centroid. Street pattern or other travel restrictions are not considered; nor are elapsed travel-time or desire-lines. Minima are desired in "U" turns in bridge-location and this single centroid method does not single out "U" turns for analysis.

[2] "Warrants and Locations for Bridges." Planning Division of W. Va. Highway Department.

b. *Double centroid*

In this procedure, an arbitrary sphere of proposed bridge influence is chosen *on each side* of the river. The centroid of each sphere is calculated, and a line is drawn to connect the two centroids. The bridge is located at the point where the line crosses the river. The disadvantage of this analysis is that it requires the arbitrary establishment of spheres of influence, neglects street pattern, elapsed time, desire-lines of travel, and "U" turn analysis.

c. *Existing traffic flow diagram*

In this method, the flow of traffic between origin and destination by way of existing route is plotted to appropriate volume scale. This method is quick, and shows general direction of travel but does not give specific line of travel-desire. Nor does it link origin to destination by individual vehicles. The procedure neglects street pattern and elapsed travel-time; and, like methods a and b, requires an arbitrary sphere of influence.

d. *Traffic transfer volume by zones*

Traffic transfers in this method are related to their zones of origin and destination by appropriate color or symbol representation in each zone by bar graph. It does not, however, correlate origins to destinations; it neglects street-pattern and travel-speed.

e. *Axial traffic flow diagram*

In this method the desire-line—or rather the component direction of the desire-line between zones—is plotted to appropriate volume-width along the river as the axis. The centroid of each band is spotted. A site may be selected at any point along this multiple band diagram, and the amount of divertable traffic obtained by measuring the width of the bands cut by the location-line, plus the width of any other bands whose centroids lie within the sphere of influence of the proposed location. The selection of the site determines the sphere of influence. Only those bands are measured whose centroids lie within the sphere of influence. This method allows for flexibility in

choosing the site, but it neglects existing street-patterns and the travel-speed.

It will thus be observed that graphical analysis is weak in several points. At best, it will serve only as a guide in site selection. A notable weakness in each is the neglect of variables in street pattern, another is the assumption of compact urban areas on each side of the river with zone layout adjusted to compensate for ratio variables.

f. *Mathematical computation*

In mathematical analysis, alternate sites are spotted. By assigning the operating costs per miles of travel, and time-costs per mile of travel to vehicles traveling by existing bridges and by the proposed bridge, it is possible to determine how many vehicles will benefit by travelling via the proposed new location. Several alternate locations are tested to compare the probable usage and the estimated construction cost.

Comparison of the benefits

It might be possible to obtain maximum *usage* by building a new bridge at one location, but maximum *benefit* (saving in total vehicle miles) by building it at another location. There should be ascertained, therefore, the user-group, the possibility of inducing new traffic, and the total economic and social benefits.

Before completing the analysis, the probable use during the life expectancy should be studied, and certainly predictions should be made as to the probable use within a reasonable length of time. In the case of a toll bridge, the prediction should at least extend to cover the bond term, in the case of the free bridge the prediction should extend to, say from fifteen to twenty-five years, in order to determine geometrics of design.

Bridge life expectancy has been variously estimated at fifty to seventy-five years in which time the population will shift and change in size. A study of the trends in growth and of shifts and economy for previous years, supplemented with data from city, regional or state planning commissions, will assist in predicting the probable future use.

Toll Bridge Location

In planning for the location of a toll bridge[1] where there is to be a toll differential between adjacent bridges, consideration must be given the distance a motorist will drive "out of the way" in order to avoid the toll. The impingement of a free bridge upon the sphere of the toll bridge, caused by the toll differential, is calculated by solving the following formula for the value of "n":

$$x = \frac{T - 4cn}{[d\,(k-1) + 2n\,(k+1)]\frac{60}{V_T}}$$

in which:

x = time-cost per minute

n = one-fourth of the extra distance travelled to avoid paying a toll, and is also equal to the differential distance which influence of free bridge extends beyond midpoint of distance between the two bridges.

T = toll charge

d = distance between bridges (or ½ of total circuit)

c = average vehicle operating cost per mile

$k = \frac{V_T}{V_F}$ in which V_T = average speed of vehicles in toll bridge sphere of influence, and V_F = average speed in free bridge sphere of influence.

As an axiom, then, the separation of the toll and the free bridge must exceed a distance of 2n before any traffic will be attracted to the toll bridge, all other conditions (speeds, volumes, attractiveness, safety, etc.) being equal. This minimum separation distance may also be obtained from the following formula:

$$2n = \frac{\text{toll charge}}{2 \times \text{total travel cost per mile}}$$

[1] "Locating a Toll Bridge for Successful Operation." 1947 Proceedings of South Eastern ASHO.

As noted, the zone of influence of a free bridge extends toward the toll bridge a distance of "n" beyond the midpoint $\left(\frac{\text{distance}}{2} + n\right)$ with a limiting separation between the bridges of 2n, if the toll bridge attracts any traffic. But whereas the $\frac{\text{distance}}{2} + n$ (free bridge influence) varies with location of the toll bridge between two free bridges, the length of the zone of influence of the toll bridge, while shifting position, does not change in length, and is equal to one-half the distance between the free bridges minus 2n, except where speeds of travel, operating costs, etc., are not uniform between free bridges. If greatly different, the value of "n" will vary for each free bridge.

For a successful venture, the toll bridge must be operated in an area economically able to support it. In other words, a zone of influence must be provided that will encompass that minimum number of trips (at the toll rate determined) to pay amortization, operating and maintenance costs.

It is well to make tests to determine the differential distance if comparable conditions obtain close at hand, rather than to make arbitrary assumptions as to operating and time-costs per mile. Studies made by the writer at three toll bridges where the basic toll was 25 cents a passenger-vehicle revealed "n" as varying from about 1.25 miles to 1.75 miles.

The mathematical solution to the problem of toll-bridge location is the most flexible, and it includes all the necessary variables of travel-desire, street-pattern and speeds. The same procedure is used, *except* that the composite cost of zone-to-zone travel by way of the toll-bridge location will include the toll charge. In this analysis, a classification of vehicles transferring between zones should be made so that each type can carry its own specific toll charge.

Design Capacity

The predicted usage will provide traffic densities for geometrical design. Probable turning movements at each end of the bridge will furnish information for approach-design. (If a toll bridge is being designed it may be well to provide three toll-booth lanes for each moving lane of traffic.)

One of the first questions asked is the number of traffic lanes to build. "Shall we build now for today's traffic, or for traffic fifty years from now?" Consider first, "Shall we build for today's traffic?" Building for "today's" traffic twenty years ago is one reason we are faced with the rebuilding or remodeling of 30,000 bridges now. Unless the bridge we build today will be adequate for traffic twenty years from now, we should consider other choices of design. We should ascertain as nearly as possible how long it will be before additional lanes are necessary. (Since the subject of lane capacities is involved, figures used here are to illustrate; they are not to be taken as ideal.)

Suppose the present usage is calculated at 3000 vehicles, the assumed capacity of a two-lane bridge is 5000 vehicles, and that *probable* usage will reach 5000 in twelve years. In order to decide how many lanes to provide, we may compare savings in costs—including interest, maintenance, etc.—of a two-lane over a four-lane bridge built *today* with the cost of *widening* or *double-decking* the bridge in twelve years. If a two-lane bridge now is the choice, later widening should be provided for as part of the analysis.

If a four-lane bridge is built now, depreciation can be included in the balance sheet. But against this, we should weigh safer, more expeditious travel. The planning engineer must assign proper weights to each of these factors which will vary with bridge type and length.

It seems impracticable to provide for traffic requirements *fifty years* from now. In the first place, a fifty-year prediction is almost sure to be wrong. And if it were considered likely that traffic volume would quadruple in fifty years we might build bridge floors today that would have to be replaced within fifty years, not from use, but from age. Again we might find a four-lane bridge required now, and eight-lanes a probable requirement in another twenty or twenty-five years. From the traffic stand-point, it might afford greater benefit to build another four-lane bridge at another point than to build an eight-lane at one place. From the stand-point of safety and capacity, the divided four-lane structure may excel the other types on a lane basis, unless arrangements are made on the five-and-six-lane bridge for unbalanced flows at morning and evening peaks.

On long-span bridges that carry capacity-loads, provision should be made to maintain the flow of traffic, despite the breakdown of a vehicle. Sometimes this is done by providing a parking lane for the disabled car, sometimes wreckers are maintained at the bridge prepared for such an emergency. A cost study will indicate which is more economical.

By all means the ultimate bridge capacity should be integrated with ultimate street capacities into which the bridge flows. A four-lane bridge may cost as much per linear foot as an urban expressway; yet too often, a four-lane bridge empties into a two-lane street that cannot be widened at reasonable cost; or into a two-or-three-lane, two-directional thoroughfare at right angles to the bridge.

Since this is so, and must be so to realize full capacity, too much restriction in speed-limit, or too many physical restrictions at approaches, may destroy the potentialities. A bridge acts as a limited-access expressway. Approaches and accessories with sharp radii must be ample in width to take the vehicles delivered, or bottleneck results to reduce the capacity of the bridge and waste the money spent in building extra capacity. Not only do sharp curves set the capacity but steep-approach grades likewise limit the working capacity of a bridge. Since approaches usually cost so much less per linear foot than the river spans, every effort should be made to keep the approach capacity equal to the bridge capacity.

Design Safety

In the matter of built-in safety the same principles apply in bridge design as in roadway design. Of prime importance is the incorporation of identical section for bridge and roadway to avoid the element of surprise that results from an abrupt change in alignment and cross section.

Of more than casual importance is the hazard of quick freezing of wet bridge-floors. When air temperatures dip to freezing points with the accompaniment of wind, the heat in the bridge floor is quickly dissipated. The result is that rain or sleet forms a glare ice. On the other hand, the approach road pavement absorbs heat from

the ground and may not freeze until temperatures dip considerably *below* freezing or continue for sometime *at* the freezing point.

Provision should be made for treatment by chemicals, abrasives, or heat, or for prompt removal of the ice by other means. Good drainage should be provided to reduce an icy condition to its minimum. The surface texture of pavement should be built and maintained as non-skid type.

Since freezing occurs quickly, curvature and grades should be kept at a minimum and ample superelevation used for design speed. If possible, bridges in snowy regions should be located so as to receive a maximum of sunshine.

Safe curbs and railings should be required also. More than once, cars have plunged through weak hand-rails. Portals should be protected against the vehicle that loses control on the approach lest it cause the whole bridge to collapse.

Another hazard is the lateral street at the immediate end of a bridge. Deck-spans will reduce that hazard by providing proper sight-distance. Congestion, however, remains even though the one hazard is eliminated.

Finally, regardless of desirable standards, some bridges will continue to be built with restrictions of width, vertical clearance, loads, and speeds. In these cases, there *must* be proper signs to warn of the restriction. Illumination of a bridge may be desirable: effect and economy should be studied.

A Summary of Planning Determinants

The bridge planner should keep the following factors in mind in locating and designing a bridge:

1. Locate for maximum use commensurate with maximum benefit.
2. Locate where safe standards can be built-in.
3. Locate where design can be planned for the required capacity for at least twenty years.
4. Locate where the bridge can be integrated with the street system, both for capacity and safety.

5. Locate where the construction cost is cheapest for benefit derived.

Reconciliation of Cost and Traffic Desire

The problem of locating a free bridge involves the reconciliation of *operational* economy with *structural* economy. Stated another way, the problem is that of getting the greatest user-benefits from the least capital investment. In some cases a shift in location is not shown in the construction cost. In this case the traffic factor rules. Often, however, a shift in location reflects itself in a change in cost of construction. In such cases, the most economical location must be found by using the *benefit-cost ratio* method of analysis.

Briefly stated, the benefit-cost ratio is the index derived by dividing the equivalent value of benefits by the cost required to provide the benefits. Of course the equivalent value of benefits and the cost of the facility are evaluated on the basis of the life expectancy of the facility. By comparing the indices derived from calculating benefit-cost ratio at alternate proposed locations, the site most economical from the overall point of view can be determined.

It is estimated that *"Thirty thousand bridges need to be rebuilt or remodeled at a cost of $800,000,000!"* Let us who are now charged with bridge-planning use all energy, wisdom, and cooperative effort that past mistakes suggested by this challenging statement are not repeated in today's program of bridge building.

Fringe Lots, Garages, Shuttle Buses Ease Congested Washington Parking

P. Y. K. HOWAT

Mr. Howat is Chairman of the District of Columbia Motor Vehicle Parking Agency. He is a member of the American Society of Civil Engineers and the Washington Society of Engineers. He was resident engineer on the only road ever built across the Dismal Swamp, and served as division engineer for the Mexican Government on construction of the road between Mexico City and Nuevo Laredo. Mr. Howat is also First Vice President of the Washington Board of Trade, Second Vice President of the Washington Building Congress and Chairman of the Advisory Board of the District of Columbia Section of the American Automobile Association. He is a member of the committee on parking for the U. S. Chamber of Commerce.

NO OTHER city in the world is just like Washington, District of Columbia. It is unique in many ways: its main industry is government; its citizens, mainly concerned with government, have no vote and little voice either in the affairs of the country they help to govern or the city they live in. Its Commissioners and other local officials are appointed by the President who is elected by Americans living outside the District; and its problems are the direct concern of every citizen in the United States.

Because Congress contributes from Federal funds to the upkeep of the national capital, the solution of local problems directly affects the pocketbook of every American. That is one reason we cannot benefit much from the experience of other cities. As Washington is like no other city in the world, her problems are unique and must be solved in ways often similarly unique.

The District of Columbia embraces some seventy square miles along the northern bank of the Potomac River, but our parking problem springs mainly from the comparatively small area commonly called our "downtown" section. This section is bounded roughly by M Street and Massachusetts Avenue on the north, Constitution Avenue on the south, and 5th and 19th Street, Northwest, on the east and west, respectively.

Into this part of Washington, comprising approximately two square miles, come more than 500,000 persons during the business hours of every working day. Here are compressed many of the large government agencies, most of the large stores and theaters, most of the business and much recreational life of the city. It is the heart of the District—and the heart of our parking problem which, if not solved wisely and promptly, will be reflected in the tax returns of every District taxpayer.

Street Pattern Is Pretty—and Difficult

In discussing the parking problem we must take into account a street system like that of no other city. It forms a pretty pattern—our numbered streets running north and south, our lettered streets running east and west, our many avenues slicing across the city in several different degrees of northeast to southwest and northwest to southeast.

The avenues intersecting the streets at many angles create some fifteen sizeable park circles, squares and triangles, and as many more smaller circles, squares and triangles, creating indescribably difficult street intersections. At Dupont Circle, for instance, ten heavily traveled streets intersect.

Within District limits live approximately 860,000 persons.[1] In

[1] Latest Board of Trade Estimate.

ILLUSTRATIONS IN THIS ARTICLE:

No. 1. Map showing relative position of downtown Washington, D. C.: main arterials leading into it, and principal rivers, parkways and boundary lines.
Prepared by D. C. Motor Vehicle Parking Agency Staff

No. 2. Main downtown areas and location of park land that has sometime been suggested for underground or surface parking.
Prepared by D. C. Motor Vehicle Parking Agency Staff

No. 3. Vehicular traffic volumes in the District of Columbia.
Permission, J. E. Greiner Co. & D. C. Highway Department

No. 4. One of the multi-deck parking facilities enlarged in Washington. Newly built section frames the original structure.
Reni Newsphoto Service

addition, the metropolitan area includes sections of adjacent Maryland and Virginia with another 500,000 persons whose economic and social life revolves around the District of Columbia. This makes a total of 1,360,000 persons whose comfort, safety and convenience must be considered in any recommendations involved in the solution of the parking problem. Besides these resident citizens, there are thousands of visitors and sight-seers attracted each year to the capital of this great nation.

Last October, 157,000 passenger cars were registered in the District of Columbia and 100,000 more in the metropolitan area. Again we must take into account the thousands of cars brought into the District each year by visitors, sight-seers and citizens doing business with their Government.

Four Bridges in 10 Miles of Potomac

To complicate our traffic and parking problems further, the Potomac River extends along the entire southern boundary of the District of Columbia, with only four highway bridges crossing the river into the District in the entire ten-mile stretch. The Anacostia River cuts the city completely in two on the east, extending from the Potomac to the District-Maryland line, and only three highway bridges cross the Anacostia within District limits. Finally, to the west is the vast area of Rock Creek Park, stretching from the Potomac to the northern boundary line. (See Fig. 1.) All of these factors tend to channel traffic into and through the downtown section, and make more difficult the location of accessible and convenient off-street parking facilities.

Perhaps a little more ought to be said about the way in which the District of Columbia is governed. The average Washingtonian has less to say about his municipal government than the average New Yorker, Texan, or Michigander who usually doesn't even know that he is a final voice in the affairs of the City of Washington.

We are the Federal City, governed directly by Congress. There is a Board of Commissioners composed of three men, two of whom are appointed by the President of the United States and approved by the Senate. The third member is the Engineer Commissioner,

who is assigned to the post, usually for a period of four years, by the Chief of Engineers of the United States Army, but whose appointment is officially made by the President.

All actions and decisions taken by the Board of Commissioners are subject to the approval of Congress, acting through the District Committees of the Senate and House of Representatives. The Commissioners spend a great deal of their time answering questions by members of these Committees concerning the management of one or another branch of the District government.

A Parking Agency Is Formed

Present efforts to solve our parking problem stem from a series of such hearings "on the hill" held in the summer of 1941 under the direction of Congressman W. T. Schulte of Indiana and Congressman F. Edward Hebert, of Louisiana. The parking problem had become so acute that hundreds of Washingtonians attended the open hearings, and numerous suggestions were made. One "solution" that quickly caught the fancy of many of the listeners involved the building by the city of parking garages under one or more of our parks—a suggestion discussed in another part of this article. What did come out of these hearings was a bill creating the Motor Vehicle Parking Agency of the District of Columbia, comprised of seven members appointed by the District Commissioners.

This bill gave the Agency, through the Commissioners, "within the limits of appropriations by Congress therefor . . . . . the power to acquire, create and operate in any manner hereinafter provided" public off-street parking facilities in the District of Columbia. The bill provides the power "to acquire any property, real or personal, or any interest therein, by purchase, lease, gift, bequest, devise or grant, or by condemnation", and the power "to undertake by contract or otherwise . . . . . the construction, reconstruction, repair, maintenance and operation of parking facilities."

In other words, the Act gives the Agency full authority to go into the parking business in practically any manner that Agency members deem advisable, desirable, or necessary.

While the Act became law in February, 1942, the Agency did

not become active immediately because of the War. But in October, 1945, the Commissioners brought the Agency to full life and put it to work under the aegis of the Engineer Commissioner, Brigadier General Gordon R. Young.

First Job Was to Get the Facts

The first task was to procure, collate and assemble all possible data affecting the parking problem and its solution. Much of this data had already been assembled by our D. C. Highway Department, headed by Captain H. C. Whitehurst, through the media of cordon counts, door counts, studies of walking distance, pedestrian concentration, modes of transportation, turnover of parking facilities, land use and land value. The Agency had chiefly to bring this data up to date, and after an aerial survey, and interviews with executives and authorities who possessed information and opinions on the subject, set forth policies to be pursued.

While the Agency staff waded through statistics, the Agency members decided questions of policy. In the District of Columbia, more than a dozen groups and organizations have a voice in traffic matters. It was believed important to get the cooperation of all of these groups, including particularly the D. C. Highway Department, the Department of Vehicles and Traffic, the Public Roads Administration, the Commissioners' Traffic Advisory Council, the National Capital Parks and Planning Commission, the Capital Transit Company, the Traffic Committee of the Washington Board of Trade, the Junior Board of Commerce, the Keystone Auto Club and the American Automobile Association with its 45,000 members in the metropolitan area.

The Agency decided the only way to get this cooperation was to formulate an intelligent and well-considered program, then to invite counsel and criticism of every phase of that program, and to give every criticism the benefit of thorough analysis and discussion. That the Motor Vehicle Parking Agency has done just this is evidenced by the fact that during the last two years it has had a most amazing degree of cooperation from every one of the organizations mentioned above, as well as from many others.

Government or Industry in the Parking Business

Another important decision to be made was whether the task could be accomplished more quickly, more economically and more advantageously by putting the municipality into the parking business, as the Agency was authorized to do under the Act, or to persuade private industry to undertake the job. A great deal of mental and physical perspiration brought forth the unanimous conclusion that private enterprise could and should cure the condition that was created by private industry in the first place. It was felt that, while Congress had given the Agency full power to go into the parking business, what Congress really wanted was off-street parking facilities, and if private enterprise would furnish these, there would be more praise than criticism from all sources. Many factors went into this decision:

Private capital has approximately $20,000,000 invested in the parking business in the District. It seemed unwise and unfair to use the tax money this industry was paying to the District to put the District into competition with these taxpayers.

Under-Park Parking Is Considered

A great deal of sentiment existed for the construction of public parking garages under one or more of our fair-sized parks. The principal ingredient of this sentiment seemed an assumption that this land was available *immediately,* which was not actually the case. The District parks are under the full control of the Federal Government, and before a single tree could be cut down to make way for underground garages, both Houses of Congress and the President of the United States would have to approve. Speed was essential. We needed parking facilities quickly and Agency members were convinced that years would elapse before permission could be secured to build garages under the parks over strenuous opposition sure to develop. Moreover, unless manifestly unavoidable, it would be too bad to destroy trees in a city so beautiful because of its trees.

Other elements entered into the decision. The cost of building a garage underground was estimated at more than treble that of

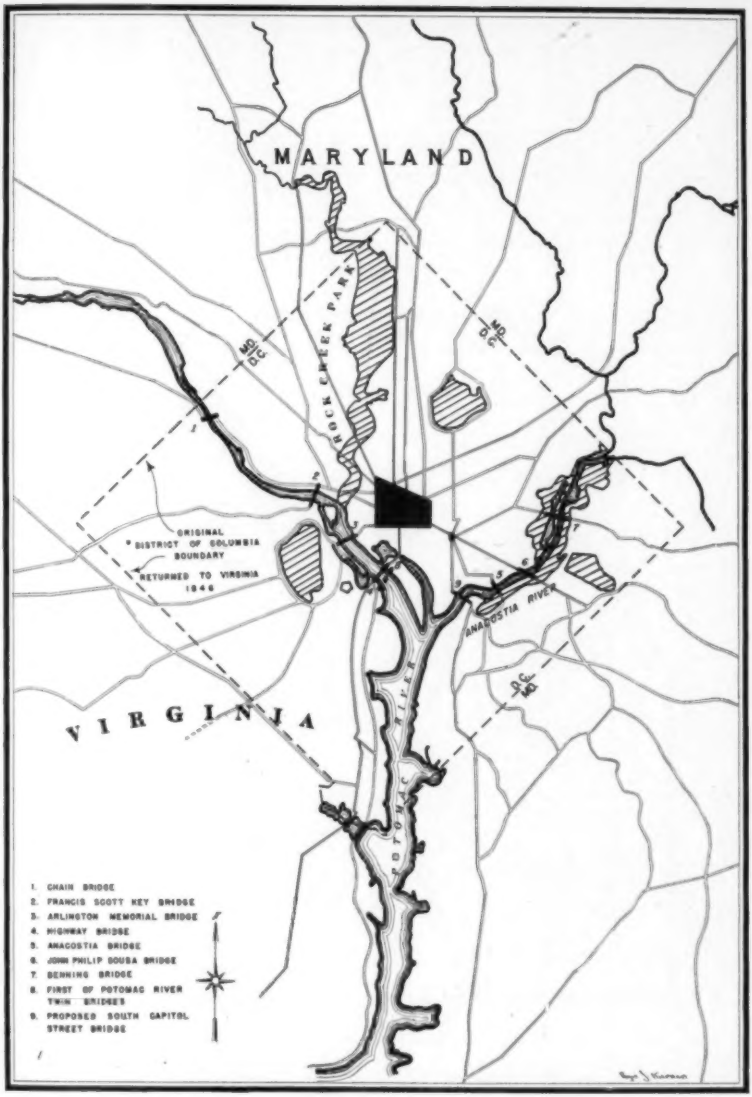
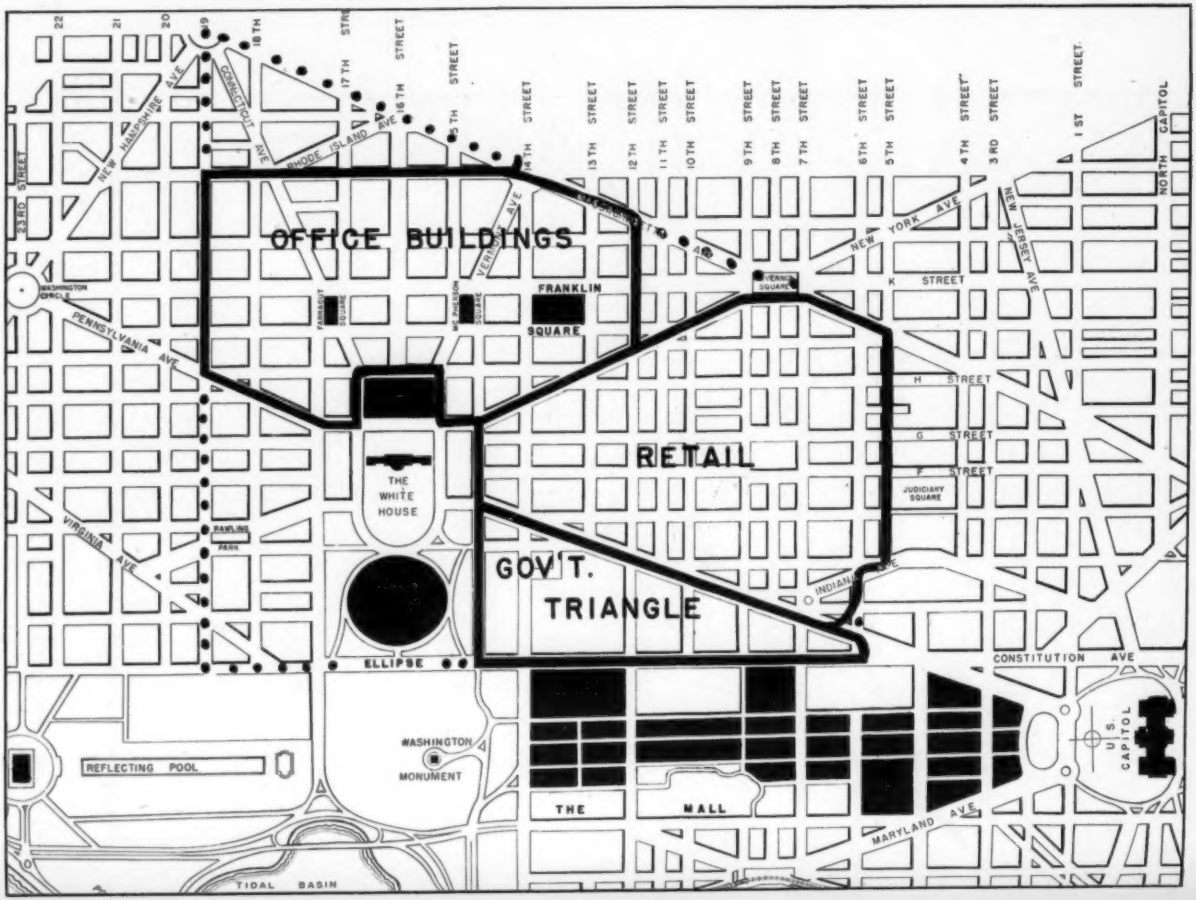

MARYLAND
VIRGINIA
ROCK CREEK PARK
MD.
D.C.
ORIGINAL DISTRICT OF COLUMBIA BOUNDARY
RETURNED TO VIRGINIA 1846
ANACOSTIA RIVER
POTOMAC RIVER
1. CHAIN BRIDGE
2. FRANCIS SCOTT KEY BRIDGE
3. ARLINGTON MEMORIAL BRIDGE
4. HIGHWAY BRIDGE
5. ANACOSTIA BRIDGE
6. JOHN PHILIP SOUSA BRIDGE
7. BENNING BRIDGE
8. FIRST OF POTOMAC RIVER TWIN BRIDGES
9. PROPOSED SOUTH CAPITOL STREET BRIDGE

FIG. 1


OFFICE BUILDINGS
RETAIL
GOV'T. TRIANGLE
THE WHITE HOUSE
FRANKLIN SQUARE
FARRAGUT SQUARE
MCPHERSON SQUARE
LAFAYETTE SQUARE
VERMONT AVE
CONNECTICUT AVE
NEW HAMPSHIRE AVE
RHODE ISLAND AVE
NEW YORK AVE
NEW JERSEY AVE
PENNSYLVANIA AVE
VIRGINIA AVE
CONSTITUTION AVE
MARYLAND AVE
INDIANA AVE
WASHINGTON CIRCLE
DUPONT CIRCLE
VERMONT SQUARE
JUDICIARY SQUARE
RAWLINS PARK
ELLIPSE
REFLECTING POOL
WASHINGTON MONUMENT
THE MALL
TIDAL BASIN
U.S. CAPITOL
NORTH CAPITOL
22 21 20 19 18TH STREET
17TH STREET
16TH STREET
15TH STREET
14TH STREET
13TH STREET
12TH STREET
11TH STREET
10TH STREET
9TH STREET
8TH STREET
7TH STREET
6TH STREET
5TH STREET
4TH STREET
3RD STREET
1ST STREET
23RD STREET
K STREET
H STREET
G STREET
F STREET

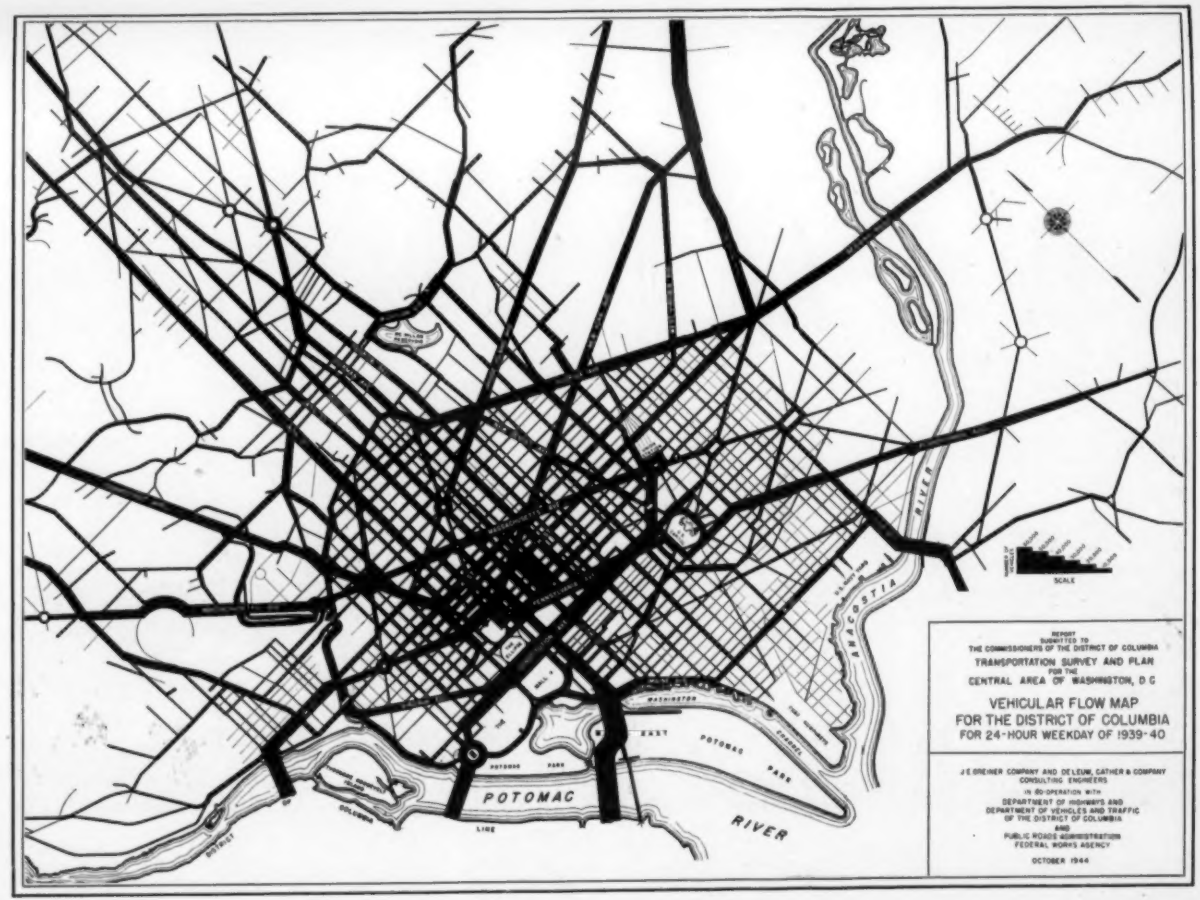

POTOMAC
RIVER
ANACOSTIA
RIVER
EAST
POTOMAC
PARK
POTOMAC
PARK
SCALE
REPORT
SUBMITTED TO
THE COMMISSIONERS OF THE DISTRICT OF COLUMBIA
TRANSPORTATION SURVEY AND PLAN
FOR THE
CENTRAL AREA OF WASHINGTON, D.C.
VEHICULAR FLOW MAP
FOR THE DISTRICT OF COLUMBIA
FOR 24-HOUR WEEKDAY OF 1939-40
J.E. GREINER COMPANY AND DE LEUW, CATHER & COMPANY
CONSULTING ENGINEERS
IN CO-OPERATION WITH
DEPARTMENT OF HIGHWAYS AND
DEPARTMENT OF VEHICLES AND TRAFFIC
OF THE DISTRICT OF COLUMBIA
AND
PUBLIC ROADS ADMINISTRATION
FEDERAL WORKS AGENCY
OCTOBER 1944

FIG. 3

FIG. 4

building it above ground. And surveys revealed that the parks are not ideally situated for conversion to parking purposes, and that what is needed in Washington is not a few big parking facilities, but rather a greater number of small garages (preferably of about 300–400 car capacity) strategically located for maximum convenience. (See Fig. 2.)

Finally, several meetings with downtown merchants and businessmen convinced the Agency members that a clearcut decision had to be made forthwith, since no sane investor would put his money into parking garages as long as he was faced with the possibility of municipal competition, as had been the case here for several years. The Agency, therefore, assured prospective investors that there would be no competition from the District if private capital would get to work in a reasonable length of time.

Persuading Private Enterprise to Act

The next big job was to persuade industry to invest in parking structures. There has been a great deal of criticism of private enterprise all over the country, of late, for not showing more interest in dealing with the parking problem. On all sides you hear the charge that private industry has failed to do the job and, therefore, nothing remains but for the government to roll up its sleeves and clean it up.

I do not agree with that charge, for these reasons:

Neither private industry nor Government can intelligently locate and construct a system of parking facilities until complete surveys have been made of the entire area under consideration; and Government can make those surveys most effectively. Much of the information needed is in official, documentary form, readily available to government agencies.

Criticism for failure to solve the parking problem should be leveled, therefore, not at private capital, but at any municipality that has failed to make survey findings available to interested businessmen. Until that has been done, the parking problem remains the fault of the municipality. It was this that the Motor Vehicle Parking Agency decided to do in the District of Columbia.

As the data collected from surveys and other sources were assem-

bled, and a general pattern became discernible, groups of businessmen and committees of various organizations were invited to the office of the Parking Agency to inspect the results. These gatherings were used by the Agency members and staff as opportunities to sell the idea that private industry would not have to face municipal competition, if private enterprise would go to work on the job.

A 3-Point Answer

Members of the Agency and its staff attended luncheon and dinner meetings of civic and other organizations. These speakers kept pounding home the same offer: *You will not have municipal competition; the Agency will conduct surveys and make the survey information available; but it is the job of private industry to provide the necessary off-street parking spaces.*

The answer to Washington's parking problem, as developed after two years of surveys and study, falls into three parts:

(A) Express buses operating via express thoroughfares;

(B) Fringe parking lots with shuttle-bus service direct to the downtown section;

(C) More parking garages and parking lots wherever they can be effectively and profitably developed.

In arriving at this solution, we were mindful of the pressing need for immediate relief, as far as was practicable, as well as long-time relief. While directing much of our effort to bringing about the establishment of new parking garages, we realized that it takes about a year and a half to build a safe, substantial structure. The question was: *What can be done right now?*

We believed an important part of the answer could be supplied by express buses using express streets from the suburbs and residential areas direct to the big government offices, thereby encouraging office workers and others who do not use their cars during the day to leave them home, which would free spaces for those who need cars in the downtown area. Express streets do not mean specially built highways, but existing thoroughfares along which traffic lights and other controls could be adjusted to the maximum continuous motion in the direction of peak-flow traffic.

Fringe Lots and Shuttle Buses

The other part of the answer for quick relief is fringe parking lots, with shuttle buses to take the load from lots to downtown area. We believed this could be accomplished during the slow and difficult construction period for the permanent garages, either by leasing or purchasing lots on the fringe of the business district, where the assessed valuation of unimproved land is not over $3 a square foot.

Our idea was to establish lots with capacities of not fewer than 400 nor more than 1,200 cars, and with frequent shuttle-bus service direct to the shopping area and government buildings. Lots with room for fewer than 400 cars cannot support the necessary bus service, while those with more than 1,200 spaces would create sporadic congestion with attendant traffic hazards.

The formula for finding the ideal location is "a lot located on the right side of a main thoroughfare, so close into town that the motorist is beginning to worry about where he is going to park, but where the land does not cost over $3 a square foot."

Many medium sized lots or garages are better for the community than a few large facilities. Fringe lots can be made attractive, convenient and profitable, and low parking rates can be supplemented by various services. One operator here in Washington is contemplating the establishment of a fringe parking lot having not only the usual services of gas and oil, etc., but also such conveniences as a playroom and trained nurse where mothers could leave their children safe while shopping or at the theater.

A Team: Municipality Plus Industry

Our efforts thus are being concentrated on developing fringe lots and adequate bus service to solve the immediate problem, and on promoting the more time-taking construction of permanent type garages.

Another way to relieve the immediate congestion, to some extent, has been put into effect by government agencies in certain areas where a large employee population is concentrated. That is the staggering of office hours, which helps to distribute the rush-hour load over one and a half to two hours in morning and evening.

In resolving our parking problem, therefore, we find the first half of the job up to the municipality—making surveys and collating information. The second half is the province of private industry—financing and operating permanent facilities by individuals or merchants and businessmen directly interested in a sound solution.

Already three parking garages have built additions adding space for 360 vehicles; two garages, previously leased for other purposes have returned 960 spaces to public parking, and a fringe lot for 225 cars has been put in operation, with shuttle bus service to the downtown area—a total of 1545 additional spaces.

Nearly Half of Down-Towners Ride Buses

The idea of express bus service has been pushed, to the extent that now nearly 50 percent of the people entering the downtown area before 9 A.M., each business day, ride on "limited stop" buses. This encourages potential parkers to leave cars at home. Furthermore, the arrival hours of government employees in the area have been staggered from 7:45 to 9:15 A.M., enabling them to secure faster and more comfortable service to their offices via streetcars and buses.

In addition to the garages and lots mentioned above, three new garages are about to be built, affording space for nearly 1,200 more cars. In all three cases, the District of Columbia Building Inspection Department has received applications from the prospective operators.

It is thus evident that progress is being made. Much more, however, could be accomplished, and would have been accomplished, were it not for the difficult construction situation throughout the country.

A movement is burgeoning among downtown merchants and businessmen to form a stock company for building and operating parking facilities in the congested area of the District. Prominent business leaders expect to promote the sale of stock to affected businesses and the general public, with official encouragement from the Motor Vehicle Parking Agency. Also, prospects are brightened by the possibility of fifteen more developments now in various promotion or planning stages, ranging in size from 50 to 1,200 cars. When

all of these undertakings are brought to fruition, they will transfer a total of more than 5,000 vehicles from curb to off-street parking.

Downtown Disintegration Was a Fear

It is gratifying to me, as a Washington businessman, to find fellow-industrialists vigorously taking up the solution of a problem that private industry created in the first place. Until the Motor Vehicle Parking Agency plan was evolved to accumulate data and place them at the disposal of commercial interests, there was cause to fear the eventual decentralization or disintegration of the high-taxpaying downtown business district.

In such case, the District would be particularly vulnerable because of its limited area and its Congressionally decreed boundaries. Businesses moving out of the downtown area have practically no recourse but to move across the Potomac into Virginia or across the line into Maryland. Carried out to its ultimate conclusion, this would mean the total de-industrialization of the District and a vastly increased tax burden on every taxpayer in the District of Columbia.

To me as a private citizen the most satisfying element of Washington's answer to the parking question is the decision to keep the municipality out of the parking business. If off-street parking facilities are really necessary, as I believe they are; if they will perform a valuable service, as I believe they will; if they can be run at a reasonable profit, as I believe they can; then it follows they ought to be in the realm of private, tax-paying industry, rather than in that of a public, tax-exacting agency.

Industry-Municipality Team Is Winning

Only those who are investing their own money, or who stand directly to gain or lose as they work well or poorly, will put forth the maximum effort. This, of course, means private enterprise.

When a city administration shows, as the District of Columbia has shown, that it is not going into the parking business, and that it is not going to continue to permit unlimited free curb parking, private facilities will be provided by private industry for all citizens

who want parking privileges and are willing to pay for them. This method of cooperation between government and industry will finally eradicate the District parking problem. And neither government nor industry could have eradicated it alone. Cooperation has always been in the vanguard of American ideals. It has always been one of the ingredients of American success. It will continue to be a prime factor in the solution of every American problem.

The City Means Nothing To Traffic

PETER P. HALE

Mr. Hale is an associate of the City Plan Commission of New Haven, Connecticut, and a lecturer and Research Associate of the Bureau of Highway Traffic at Yale University. He is also vice-president of a technical planning firm at New Haven. He was formerly in the engineering division of the New Haven Railroad.

WHEREVER *traffic*—in the early sense of a movement of men, goods, or services on foot or by animals—has reached a terminal transfer point such as a port, or where one course of movement has crossed another, men have settled there to trade with and to serve this traffic. Out of these settlements grow cities sized in proportion to the volumes of men and goods coming into or through them.

By-passing the obvious effect of geological and geographical elements, traffic becomes the next most influential factor on the form and shape that cities take. If a metropolis develops at the junction of three great routes, it will assume a shape basically trigonal. The structure of the street pattern within this basic shape is determined by the dominant mode of transportation and the function it is to perform.

The width of streets in residential sections of ancient cities was scaled to easy passage of pedestrians going from home to market. Pedestrian speeds demanded no attention to turning radii, nor did foot traffic create any extraordinary clearance problems. The time-distance limitations of foot travel dictated an extremely tight, densely populated urban development. Ancient Rome had tenements over six stories high that satisfied the demand of a great population to be within walking distance of the center of the City.

Close inspection of the pattern of any city built at any stage of history will show whether the dominant mode of transportation during the period of its growth was pedestrian, wheeled, fast or slow. And what is more interesting, if the life of a city has spanned a long-enough period of time, its phases of growth during various eras of transport development will appear as a series of concentric circles embracing areas of constantly decreasing density resulting from in-

creasing vehicular clearance demands, higher travel speeds, greater turning radii requirements and additional population mobility accruing from the constantly rising time-distance factor.

On the strength of this hypothesis, it is safe to say that traffic has given cities their form, and that therefore, traffic will change cities' form, or take it away altogether.

The City Is a Myth

After centuries of slow evolution of transport means and urban confinement, American civilization has suddenly reached the threshold of an era of which man has always dreamed—an era in which he can move as far on land as the quickest animal, and soar as high in the sky as the greatest bird. At last his facility for moving himself and his goods has achieved what once was regarded as absurd to contemplate.

His new facility, however, raises new and complex problems out of old, well-founded concepts. The idea of flight focusses new light on national and regional development. Movement in the air, being governed only by weather belts, minimizes the importance of geographical factors. Where planes touch the land in unexploited regions, urban areas based on a whole new concept of movement will develop.

The distance-factor, so important on the land, ceases to have much meaning, thereby leaving the time factor supreme. The present idea of a city, except as a terminal, ceases to have meaning. Man's increased mobility on the ground delivered by his improvement of the automobile into a high-speed vehicle removes those static restraints imposed up to now by the low time-distance ratio of animal speeds. These great technological improvements are the result of a constant, driving yearning to go further, faster, and more easily.

If the existing form of our cities denies the fruits of these inventions, urban forms are going to have to change, or cities will disappear. The majority of men have no stake of ownership in this environment. They are there by inertia, because of economic restraint, because the time-distance factor has kept them close to their work, or in the case of a few, because they like it.

Three of these four reasons for remaining in the city are dis-

pelled by general automobile ownership as now known. It is, therefore, within the powers of the automobile—of traffic—to drain the city dry. Mass flight to the country began with the trolley car. Then, there were rural sections within the city limits so the city still had meaning as a unit of growth. The tenement population began to scatter into renovated dwellings deserted by those who could afford to move out to the "end of the line."

The first forms of decentralization began bringing the first problems of reduced municipal tax returns from devalued central property. Amplification of this basic process has shifted a tax burden, once fairly uniform, to the backs of commercial and industrial properties mainly. Ample supply of electric power on an area basis, a low-cost, dependable transportation of fuels, and a mobile labor market have allowed industry to join the flight from high taxes and congestion's exorbitant costs of inefficiency.

In many cases, these flights of population and their attendant functions have skipped right over undeveloped areas still remaining within city limits and gone to the surrounding country. Except in rare cases where the city has a port or some other facility that cannot be duplicated or improved by removal, the city has lost meaning to the car owner just as it has to the pilot. As a place to live, to work, or to find general recreation, it is fast becoming a myth.

The Phoenix Is the Metropolitan Area

The Phoenix rising from the ashes of the City is the *metropolitan area* or, as already designated in some isolated, progressive instances, the *metropolitan district*. Two principal reasons exist for the growth of metropolitan areas; under them can be placed innumerable subtitles.

The first cause for development of the greater *district* in contrast with disintegration of the old *city* into several scattered urban units is that many cultural, institutional, and economic units depend on large populations for support.

The legitimate theater, for example, because of its selective appeal, demands a large population upon which to draw if it is to succeed without subsidy. Complete, large libraries cannot be supported

by small population groups. Technically perfect and well-staffed medical centers must have the financial support that can come from the wealth of large areas only.

Small populations do not warrant highly specialized schools. The advantages of large pools of capital supplied by large central banks cannot be found in smaller centers. The economies of heavy-volume purchase and sale afforded by the modern department store result from serving the demands of large populations. Also in the picture are such intangibles as the ability of the city to satisfy the human urge for gregariousness by supplying places of color and excitement as gathering places for crowds.

The second principal reason for the metropolitan area is the enormous capital investment in cities today. It is not the investment in public works so much as the private investment in factories, stores, apartments, and such structures that hinders the full, immediate disintegration of the city into a series of scattered urban centers. The owners and agents of private investment constitute a powerful force against movement; they develop an enormous inertia.

People are not dissatisfied with what the city has to offer. They are drawn in by its advantages and by the tales of greater opportunities and higher standards of living. During the last half-century the ratio of urban dwellers to farm dwellers in the United States has been increasing constantly until well over half the country's total population now lives in urban areas.

People are dissatisfied with their *environment* within the city. They are denied peace and quiet during the day, either at home or at work. They are denied contact with the soil, and therefore have no opportunity to satisfy that basic human urge to watch things grow. They are denied the privilege of daily recreation because of lack of space. They cannot leave their homes without exposing themselves to the hazards of congested public ways.

Nor can they travel from place to place within the city without great expenditure of time and effort. They no longer have to put up with all this. Universal family ownership of the automobile, and improved, rapid mass-transit is delivering the population into the metropolitan area where benefits of the City remain within reach but its curses are to itself.

Time Bounds the Area

The city-limit was a wonderful thing when it was three or four miles out from the center, when it was the destination for a good day's hike, and when it marked the "end of the line." It was significant of the outer boundary of gracious, cultured, civilized living. Traffic has turned the definition of this limit into an exactly opposite meaning. The city limit now is the boundary within which taxes are high, congestion is unbearable, and living in general is to be questioned.

Beyond this limit there is no fixed boundary. The metropolitan area is a functional unit whose extent is determined by the time-distance factor of the transportation media. This time-distance factor is flexible, varying upward with the improvement of distributor routes. In enormous centers such as New York City, volume travel by train carries the daily influence of the city out forty-five miles from its center. Construction of limited-access highways has extended the daily commuting distance by great numbers of cars nearly thirty miles.

Cities under the 500,000 population class are assuming the role of "center" to developed metropolitan areas with radii of twelve to fifteen miles. As these areas increase in size and importance, the boundaries of the cities and suburbs or surrounding towns decrease in importance except as taxing districts and Post Office indices. Those boundaries have lost meaning as measures of distance in an age when distance is only a matter of time and when time is principally determined by the speed of a car.

Can The City See its Image in the Area?

The metropolitan area is the product of the motor age, a modern expression of the influence of traffic on city growth. But it does not show clearly by its pattern the medium of transportation that has created it. In most cases, the city boundary has disappeared beneath an extension of the wholly inadequate, repetitious angular pattern that traffic is fighting to change. The image of the city is reappearing beyond its limits and responsibility is threefold.

The average man, buried in this morass, cannot be expected to

do anything about it. He is too busy getting back and forth to work to satisfy his daily requirements. His plaintive cry is drowned out by the ballyhoo of real estate promoters who got him out there in the first place by appealing to his dissatisfaction with something deeper in the city that was a little worse.

The first responsibility lies with the leadership of communities affected by this expansion. As leaders in the establishment of policy, they are opening themselves to criticism as being downright ignorant if they refuse to profit by the mistakes of the past, which are forcing their present burdens upon them. The sensible far-sighted attitude is one of action for the general benefit of the whole metropolitan area.

It is no longer uncommon to find towns surrounding a city united in the establishment of a metropolitan-area planning-body of some sort, although this action has not become usual. The duties of such a body are to evaluate the resources of the whole area, developed and undeveloped, natural and man-made, and to evolve a scheme for the ultimate maximum use of these resources. Some areas will be best suited to industrial exploitation; others will be best used for general recreation; particular parcels will appear ideal for shipping centers; and finally, districts carefully related to these others mentioned will be set aside for residential use.

Along with such zoning for most beneficial and economic use of the land, it is the responsibility of such a planning body to set forth a code of minimum regulations to guarantee minimum street-widths and turning radii based on today's vehicles and in anticipation of tomorrow's requirements. This code should make sure that every man gets the space, light, and air for which he has come out of the city. It is the planning body's responsibility also to set forth minimum codes in regard to off-street parking to insure the effectiveness of operation of public ways built at great expense. The skeleton of this whole scheme of organization and growth is the transportation system.

The second responsibility lies with the traffic engineer. He is a specialist in modern transportation. This whole problem is an outgrowth of technological improvements in transport media which puts it up to the traffic engineer to stimulate the imaginations of

unenlightened civic "leaders" and to apply the tremendous influence of properly channeled traffic toward bringing about the ends desired by the metropolitan planning body.

It is up to the traffic engineer, always cognizant of the effect of his medium on land use, not to be trapped by designing thoroughfares on the basis of today's origin-destination counts plus some small factor for increased car ownership in the next five years. In fairness to the correct conception and development of the whole new urban district, it is almost a professional obligation of the traffic engineer to grasp these opportunities to create a perfect civic expression of the motor age even at the expense of allowing the city proper to languish until this first job is done. If these elements of potential growth are not well considered, the engineer will, as Henry Churchill put it, "be building obsolescence."

The third responsibility lies with the real estate developer. In the beginning of the nineteenth century, when continued expansion of this country seemed to be guaranteed, the tracks of the developer and speculator began to appear on the peripheries of the tiny cores of today's great cities. The tracks of the developer and speculator are grid-iron street layouts. The only more permanent mammal-tracks on the face of the earth are the dinosaur footprints embedded in geologically recent shale formations in New England and in other scattered parts of the continent.

This grid-iron layout is a mechanically perfect indexing system: a series of straight lines, it is the simplest pattern of land subdivision; by its geometric regularity, it allows the building trades to approach assembly line efficiency in dwelling construction; by its utter unimaginativeness and complete disregard for land forms, it requires no thought whatsoever for its application; by its multiplicity of street intersections, it does the utmost to bring traffic to a halt and raise hazards to a maximum; by its own regularity and the uniform type of construction it engendered, it does more than almost anything else in daily life to reduce the normal, struggling human being to the status of a "common man"—the grid-iron layout, universally the monument of the developer and land speculator.

Fairly recently, some men in the real estate field have been pointing the way *out* of this habit. Some, assuming that the car is here to

stay, have capitalized on that belief by designing attractive subdivisions accordingly and have created shopping centers that give the customer in her car the same consideration she receives when she actually enters the store.

During this period of expansion and adaptation, it is imperative that this group of men assume the share of responsibility that falls to them. Improved, attractive, modern layout is not a matter of cost, as shown by the example of one of the great builders on Long Island. It is mostly a matter of principles.

Unless these three groups, the planners, the traffic engineers, and the developers get together, the city's image is bound to reappear in the metropolitan area out of habit, if nothing else. The problem is to reduce the importance of habit in these operations, to apply thought and logic, and so cut out the time-lag and years of wasted effort which habit creates while it reluctantly changes.

The city means nothing to traffic. There is nothing holy about land values, land ownership, city finance, bankruptcy, or any of the multiple facets of the municipal structure. If their agents refuse to gear them to modern traffic demands, the unlimited mobility that traffic offers will allow the tremendous economic power it represents to move off to the environment it seeks—in a new urban center, a metropolitan area, or even in another region.

Traffic is not a curse destroying something that is good. It is an instrument of freedom high-lighting obsolescence, provoking thought and action—a powerful new tool with which to build.

The Uses of Accident Records in a State Traffic Program

CAPTAIN W. L. GROTH

Captain Groth is Safety Engineer of the Virginia Department of State Police. He joined the Virginia State Police in 1934, and has been promoted through the ranks. He served as an instructor in Traffic for the Federal Bureau of Investigation during 1942, and is now a guest lecturer at the National Academy. He is a past chairman of the Police Division of the Traffic Section of the National Safety Council and is a vice-chairman of the Traffic Section of the National Safety Council. He also serves as vice-chairman of the Engineering Committee of the A. A. M. V. A. He is a past president of the Virginia Society of Engineers, an associate member of the Society of Automotive Engineers, and a member of the Board of Consultants of the Eno Foundation.

TRAFFIC policing today is big business. It is big business because it either directly or indirectly affects every man, woman, and child. It is big business because it deals with a problem—the traffic accident problem—which according to 1947 "Accident Facts" cost the nation $2,200,000,000 in 1946. Of this total, $900,000,000 represents property damage.

Traffic policing, moreover, is big business because in its hands rest the safety and well-being of countless millions of highway users. Proper records provide business organizations with a picture of the past and a look into the future. No first-class business can exist long today unless its records are complete and properly analyzed.

Traffic accident records are the basis for any sound traffic safety program, and no police department can direct a worthwhile traffic enforcement program during this mechanized age without having available factual data upon which to base that program. In the not too distant past, many police administrators considered their sole duties to be in the apprehension of criminals. They were in no way interested in what we now consider good policing, the policy of trying to *prevent* accidents.

Those administrators of the old school, the "lock 'em up type," are as out of date as a Model-T Ford on today's competitive market. Truly great strides have been made in over-all policing, and much of that improvement has been due to the installation of modern accident record systems with trained personnel to properly evaluate the wealth of accumulated information.

Accident-Reporting Methods Vary Greatly

In considering this subject on a state-wide enforcement level, we must remember that no one standard procedure is used by the many agencies of state government charged with collecting accident data. In some states, this collection duty lies in the motor vehicle department. In another state, it may be the responsibility of the highway patrol or state police. In a few states, the highway department is the collecting agency; in still others, the duty is that of the vital statistics section of state government.

There is also wide variation in the kind of accident reported. In most states, all fatal and injury accidents must be properly and promptly reported. There is, however, wide difference in the reporting of property damage accidents. Some states require the reporting of this type of accident regardless of the amount of damage inflicted, whereas in thirteen states, the amount of damage must be at least $25; in twenty-two others, $50; and in still another, $100. Needless to say, with this variation in reporting, it is important to bear in mind that national figures are not completely dependable.

At the time of this writing, forty-five states in the nation require operators to report all accidents resulting in fatalities or personal injury. Forty-two states require the reporting of all fatal accidents, all injury accidents, and property damage accidents of varying degree. There are three states that do not require operators to report any accidents.

Obviously more uniformity is needed on a national basis, and we in the traffic-accident field should encourage compulsory reporting of *all* accidents and should support legislation *requiring* such reporting according to the standard recommended in the Uniform Vehicle Code.

Specific Uses of Accident Data

Policing today on a state-wide basis presents many, many problems. The state administrator is faced with the problem of assigning his personnel to sections of the state where they can render the greatest public service. He is faced generally with the problem of directing the traffic enforcement effort that is to be given to rural areas. He has the problem of developing within his own organization the realization that traffic enforcement is important and desired by the public.

He has the added responsibility of selling to the *public* the importance and value of the traffic enforcement program. He must have some means of determining just what enforcement steps are to be taken if he is to fulfill the aim of good traffic enforcement; that is, "to provide the public with a maximum of protection with a minimum of interruption." Such information is largely available from data secured from properly-filled-out and properly-analyzed accident reports and from traffic-flow information.

The desire on the part of the enforcing agency must be sincere; first, to prevent traffic accidents and, second, to prevent congestion. In handling the traffic problem in any state, there are several basic factors that must be carried out. Regulation by means of signs and signals must be utilized. Control by physical means or by direction must under certain conditions be used.

Enforcement must be directed against violations which may be intentional on the part of the violator or performed through ignorance or lack of knowledge with the sole idea of discouraging a repetition of such violation. Accidents must be investigated in order that all facts may be secured and, if violations have occurred, that prosecutions may be made. Accident prevention and violation prevention must be continuously carried out through routine patrolling of potential accident routes.

Obviously, if a state enforcement agency is to give proper protection to users of the state's streets and highways, then the planning for such protection must be based on as many known facts as can be brought together. We will recognize that the four main factors in any traffic control problem revolve around the car, the roadway, the

driver, and the pedestrian. We must, therefore, obtain as much information on each of these categories as we possibly can, and also determine, in so far as possible, just how important a part each plays in the accident picture and in the enforcement picture. Such information can largely be obtained from accident record data, from surveys, and enforcement activity data.

Properly Trained Personnel Is Needed

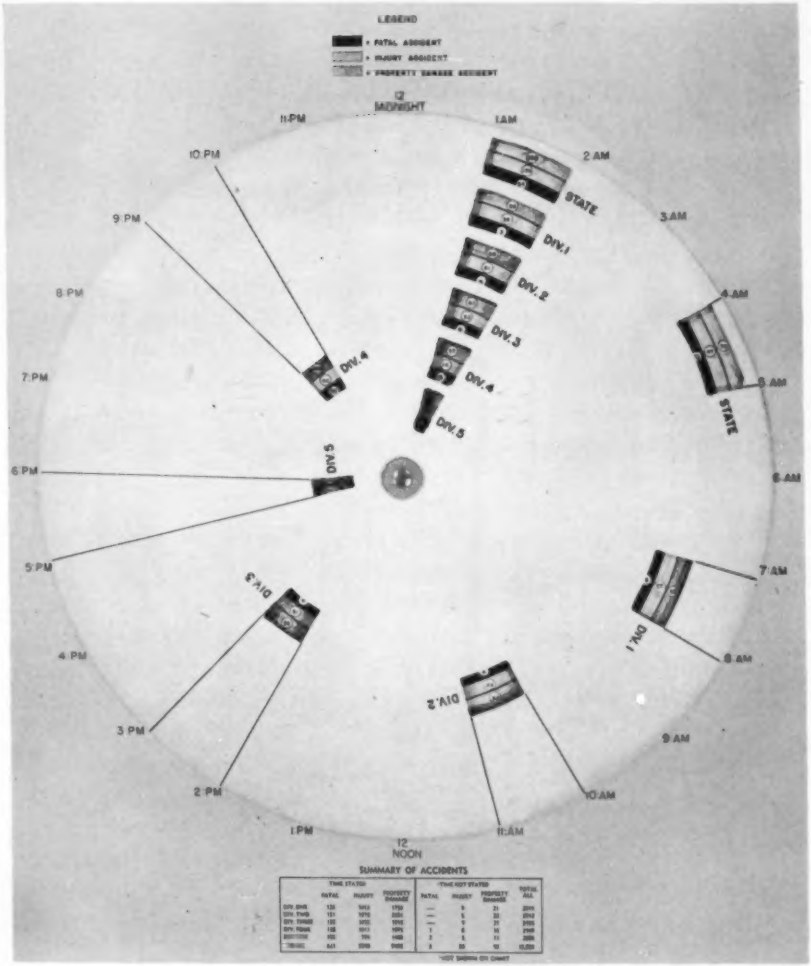
We cannot afford to overlook the importance of combining information from all these sources. Many persons in the traffic enforcement field, whose views are highly respected, question the advisability of using information for enforcement guidance when such information is furnished by a citizen through compulsory accident reporting procedures. It is my opinion that if it is known such information, when furnished, will not be used for civil or criminal prosecution purposes but for *accident-prevention purposes* alone, the public will respond with an attempt to give a true picture of the facts as they see them.

Investigating officers who conduct complete investigations at the scene are, of course, more apt to give an unbiased view of what they think occurred. Their views are based upon physical facts visible at the scene and upon information secured from persons involved and from witnesses. We cannot overlook the fact that all police have not yet been properly trained to conduct investigations. Occasionally, therefore, the police officer's report has little value.

Proper training of police is increasing rapidly, but we must admit there still is much need for giving emphasis to this all-important part of the enforcement program. We cannot by any stretch of the imagination assume that all accident reports made out by the police give all the details in which we are interested, since much of the information they give is obtained from others through verbal questioning and may be distorted.

Accident data is unquestionably the key source of information an administrator uses for his guidance, if he is to combat successfully an acute traffic-accident problem. He must first know what that problem is. He must know where it is occurring, when it is occurring, and

ACCIDENT TIME CHART
1946
State by Hour
Divisions by Hour

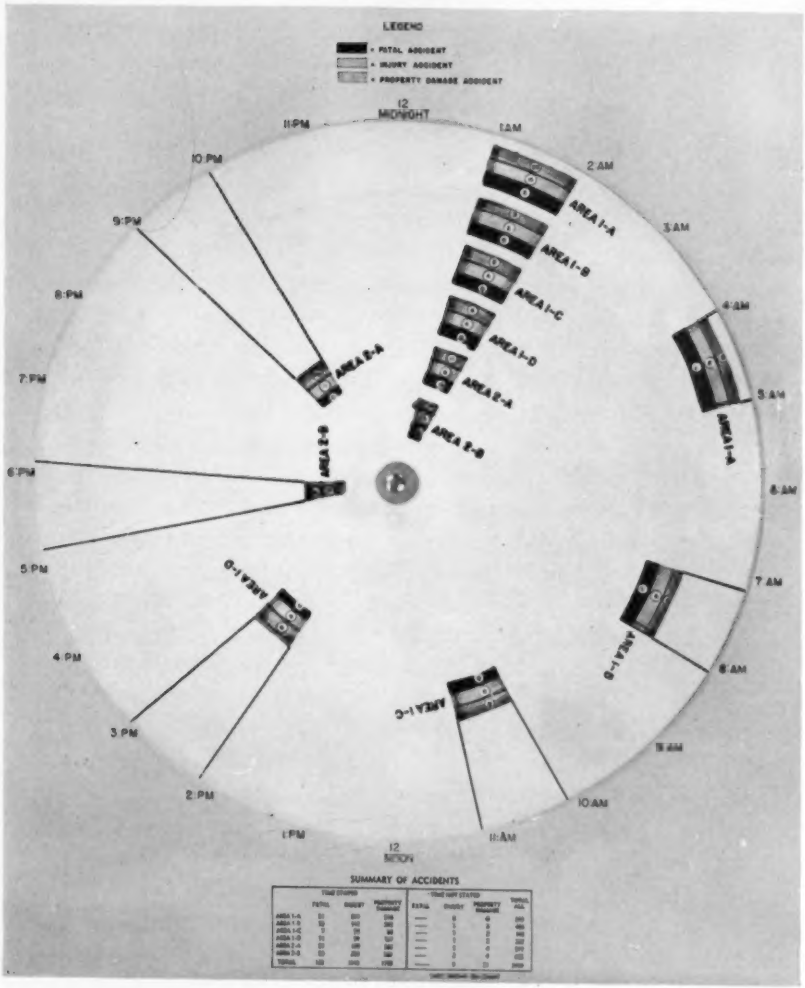


SUMMARY OF ACCIDENTS

	TIME STATED			TIME NOT STATED			
	FATAL	INJURY	PROPERTY DAMAGE	FATAL	INJURY	PROPERTY DAMAGE	TOTAL ALL
DIV. ONE	135	1013	1758	—	9	21	2936
DIV. TWO	121	1070	2026	—	5	30	3252
DIV. THREE	135	1072	1990	—	9	31	3237
DIV. FOUR	158	1011	1975	1	8	31	3184
DIV. FIVE	90	716	1468	2	5	11	2292
STATE	641	5598	9982	3	36	124	16,506

*NOT SHOWN ON CHART

ACCIDENT TIME CHART
1946
Division One



what causes it to occur. In other words, he must be able to locate the sore spots or the trouble spots, and to direct attention to them at the time and against the conditions causing them. Accident records provide that information, but such information must be painstakingly picked out of each report, properly logged, coded, and recorded.

Herein lie some of the weaknesses of many state enforcement programs, in that an insufficient staff of trained personnel is not being provided to perform that all-important function. The result is that many states have only a smattering of statistical data of little value in enforcement planning. Sufficient trained personnel and adequate funds for analyzing records must be provided if the true value of any accident-reporting system is to be attained.

The theory of traffic accident prevention is based on the concept that if dangerous or hazardous physical conditions of a surprise nature are removed, and if dangerous actions on the part of drivers and pedestrians are curbed, traffic accidents can be prevented. It appears logical to assume, therefore, that accident records are fundamental to any accident-prevention undertaking. We certainly must know what it is we are trying to prevent before we can sensibly plan a method of attack. By the same logic, it would appear necessary that we know all the contributing factors involved.

The use of spot maps as guides to the location of accidents is one of the necessary steps in the diagnosing of the accident problem. By properly spotting the location of accidents, the attention of the analyst is soon attracted to a specific intersection or high-accident area. He can then refer to reports or coded data for whatever special study attention he deems necessary. The spot map will show the pattern trend of accidents throughout the state, and is one of the best "attention getters" used in the study of accidents.

Locating High-Accident Areas

It does not necessarily follow that the accident pattern will remain similar to the traffic volume pattern. Ofttimes a properly kept spot map, when compared to the volume map for the same area, will show that one stretch of roadway has a disproportionate share of accidents.

This factor then requires special study, and engineering or educational or enforcement needs might be found to be necessary in order to eliminate and prevent a similar experience in the future.

The legend used in keeping spot maps can, of course, be set up to show the particular phase of the problem desired by the analyst or administrator. Generally, accidents should be spotted in order that property damage, injury, and fatality can be easily distinguished. It appears also that since the pedestrian continues to furnish about one out of every three fatalities recorded, the master spot map should also show the location of that type accident. Further breakdowns of spot maps into day and night or to show hour of day, of course, have value, and can be set up to show at a glance almost any particular phase of the accident picture desired.

It stands to reason that we cannot properly spot accidents on a map unless they are reported; so without a good reporting of traffic accidents, we cannot hope to obtain a correct accident-location pattern. The use of police reports only for spotting accidents is in my opinion a mistake, since in many states thousands of individual accident-reports are filed on cases that are not investigated by police and often are unknown to them. Being able to locate the high-accident areas is one of the administrator's greatest assets in directing his enforcement and safety promotional work. The spot map, to my way of thinking, fills a valuable need in traffic-accident prevention work both from an enforcement and engineering standpoint.

Special Uses of Accident Data

Special uses of accident report data are, of course, to be encouraged. The pedestrian problem in almost every state and community needs, and is entitled to, special attention. Night traffic-accident problems have not yet had the study and attention due them. We can learn much by back-tracking our study into the thousands of night-accident cases that have been reported. Surely, whenever more than 50 per cent of our traffic accidents occur when less than one-third of our traffic is moving, there is need for special study of that problem. Proper use of the information available from the reports of thou-

sands of night crashes can easily result in greater night-safety for both drivers and pedestrians.

Accident data is an invaluable aid in public relations. Many persons unfamiliar with the overall accident picture are apt to suggest enforcement that would be neither logical nor possible, for their suggestions usually are based on personal opinions or hearsay. The administrator with the complete facts at his fingertips is in a position not only to defend the policies of the department but also to show that his organization is being operated in a business-like manner with its policies based on facts.

Having such information readily available makes it possible also to "knock out of the window" the one idea that is prevalent among laymen—that traffic signal-lights are the only solution to an intersection problem. Many such requests will be withdrawn by the proposer when he is shown that certain fundamental rules and warrants are used in the installation of such lights and that such accident warrants do not exist for the particular intersection in which he is interested.

Accident totals, trends, and rates derived from accident information are definitely needed if the size and severity of the problem is to be known. Accident summaries also can provide the administrator with a fair and impartial estimate of the effect of the department's efforts in accident prevention work. When used over a period of years, these summaries can provide a before-and-after picture that will stand on its own "two legs" to prove whether or not the program instigated is producing results. Accident data provide one of the few known measuring sticks that makes it possible to show progress or lack of progress in traffic-accident prevention work.

Information correlated from accident summaries must provide the basis and meat in any public education program designed to prevent and eliminate traffic accidents. It is the key source of punch material for use in pedestrian education, a field that has hardly been scratched. Driver training programs, beginning at last to become fairly rooted in most sections of the country, have an ally in every accident-summary sheet in the nation. The experience of the young, untrained driver is reflected in the columns of the accident sum-

mary: it shows that youth of the nation need driver-training. Summaries can be developed also from a number of case studies that show the *trained young driver* as rarely the victim of his own or another's carelessness.

Accident Data in School-Patrol and School-Bus Uses

Many persons are opposed to the use of school-boy patrol. Here again, however, the accident records can prove that school-boy patrols have played an important part in the splendid record built over the years by America's schoolchild who has become so safety-conscious when afoot. By location studies of accident records covering cases occurring near schools, improved safety precautions can often be made. Every parent can rest more easily when he knows that his child is being protected through past experience as shown by record and future planning based on past experience.

Each morning throughout the nation thousands of school-bus drivers transport millions of America's most precious cargo, "her children." These buses roll regardless of weather, regardless of road conditions. They must move over routes considered dangerous and through intersections that are hazardous. They cross thousands of unguarded railroad crossings daily.

Accident records can be used to a decided advantage in the school-bus program: first, in the consideration of safe school-bus routes; and second, in the instruction of drivers on the particular accident causes for the routes over which they operate. Many discussions as to the safety of one age group of school-bus driver over another can be determined also by the accident-experience of age-groups in the accident summary.

The average person, when he thinks of enforcement, thinks only of the police. There is, however, another important cog in the enforcement picture. That cog is the American court, in which are heard thousands of cases pertaining to traffic violations and traffic crashes. The courts of the nation should be provided with the accident picture of the community over which they preside.

Accident record summaries provide the courts with a background picture of the human suffering and deaths caused by unsafe

driving and walking practices. They provide the breakdown causes and emphasize the traffic violations that are prevalent and that need *special* attention. They also help the courts to better understand the police activity in the driver-control field. Only through a thorough understanding of the community's overall accident problem can the court capably and fairly handle the accident repeater.

The expression, "Driving is a privilege and not a right," is becoming more and more true as motor vechicle administrators use the authority given them in the power of suspension and revocation of drivers' licenses. No state is adequately using its accident records unless it is using them in the "driver-control field." In every state the names of numerous individuals begin to crop up from time to time as a result of their being involved in repeated traffic mishaps. Usually they are guilty of negligence, and have the wrong attitude toward driving; in many cases they should be permanently removed from behind the wheel. Unless proper accident records are on file and unless such records are properly used in weeding out the unfit and unsafe driver, we can never expect to show real progress in the accident-prevention field. The hearing's officer for a driver-licensing department has a powerful and effective weapon in his hands when he has available the accident data for his state.

Accident Data for the Engineer

Perhaps one of the most valuable uses of accident records lies in their use from an engineering standpoint. The average street and highway built today are designed to last structurally at least twenty-five years unless "stage" construction methods are employed. It is, therefore, most important that all new construction be made with an eye focused on future safety of such street and highway. Certain accident experiences for various roads or lane widths, for certain sight distances, for certain types of surfaces are most valuable to the road builder attempting to build safety into the highway of the future.

The engineer needs accident experience data to assist him not only in his design but also in his use of signs, signals, and markings. It is common knowledge that it is not always possible to predict traffic safety of a highway in advance. This has been proved by recent

facts released on the Pennsylvania Turnpike accident experience. The engineer must, however, have directed to his attention any and all accident causes that are even faintly related to the highway itself and to its operation if he is to be able to properly incorporate such experience into his planning for the future.

The motor vehicle designing and maintenance engineer can also use to advantage accident record data, particularly that which is noted as pertaining to mechanical failures of the vehicle and to mechanical maintenance problems. Accident data of this nature are also usable in showing the need for compulsory motor vehicle inspection programs and for directing enforcement attached to the maintenance problem.

The uses of accident records are almost unlimited in scope. Certainly these views can be concluded by stating that accident-prevention work must be based on factual information and that a part of such information can be obtained only through prompt and proper reporting of traffic accidents. Certainly the multitude of uses of such records more than justify the soundness of the accident-reporting theory. Whether or not a state or municipality gets its full value from such a system depends on the uses to which it is put. The success of the program depends on the human element, the unpredictable.

Cyclists Complicate Urban Traffic in the Netherlands

DR. J. G. RAMAKER

Dr. Ramaker is an economist of the Rotterdam School of Economics and the University of Brussels. He is the author of a book on transport and traffic in Dutch cities, a member of the Board of Directors of the Netherlands Tourists' Association, and he serves as economist for the Housing Department of Rotterdam. He took part in traffic studies for the reconstruction of Rotterdam. Dr. Ramaker is also Director of the Netherlands Traffic Institute.

(A TRANSLATION)

WHAT SHOULD a citizen of the Low Countries have to tell Americans about traffic problems? The largest cities in the Netherlands have fewer than a million inhabitants and life is far less motorized than in the United States. But—and this is why I accept the editor's invitation to write this article—urban traffic in the Netherlands has some special features not to be found in many other countries. Hence it may interest Americans.

As the following pre-war figures show, the number of motor vehicles in Holland is not large, even in comparison with other European countries of similar standards of living:

	kms	*Inhabitants*		*Total*		
Countries	x *1000*	x *1,000,000*	*p/kms*	x *1000*	*p/kms*	*p/ 1000 inh.*
Netherlands	34,2	8,7	251	149	4,3	17
Switzerland	41,3	4,2	102	73	1,8	18
Ireland	84,4	3,0	36	62	0,7	21
Germany	552,0	73,4	133	1612	2,2	22
Norway	323,6	2,9	9	80	0,2	27
Belgium	30,4	8,3	273	224	7,4	27
Sweden	448,3	6,2	14	192	0,4	31
Denmark	44,4	3,7	83	145	3,3	39
France	550,9	41,9	76	2192	4,0	52
England	225,7	46,3	206	2419	10,8	52
U. S. A.	7839,0	129,3	16	29605	3,2	229

[TABLE CONTINUED ON NEXT PAGE]

Note: Motorbuses are included in the total; vehicles on 2 and 3 wheels are not taken into account.

Countries	Private cars			Goods vehicles		
	x 1000	p/km2	p/ 1000 inh.	x 1000	p/km2	p/ 1000 inh.
Netherlands	94	2,8	11	51	1,5	6
Switzerland	56	1,4	14	16	0,4	4
Ireland	50	0,6	17	11	0,1	4
Germany	1240	2,2	17	359	0,7	5
Norway	47	0,1	16	30	0,1	10
Belgium	144	4,7	17	78	2,6	9
Sweden	134	0,3	22	53	0,1	9
Denmark	103	2,3	28	40	0,9	11
France	1601	3,0	40	493	0,9	12
England	1842	8,2	40	490	2,2	11
U. S. A.	25343	3,2	196	4235	0,5	33

Note: Motorbuses are included in the total; vehicles on 2 and 3 wheels are not taken into account.

One should remark, however, that the small number of motor vehicles in relation to the number of inhabitants gives a high figure for the relatively small area. Motor vehicles per capita in Holland are exceeded by only Belgium and England, and they exceed in density, as it were, even the United States. In a small country, where the longest journey can easily be made by car in a day, traffic in both cities and countryside is relatively heavy. The proportion of trucks (more intensively used than private cars) is high. Yet much carriage of goods is by canal and rail. All in all, the motor vehicle is relatively more important as a congestion factor in traffic than as an economic factor in transport.

But if the majority of citizens in the Netherlands do not travel by motor, neither do they go from one part of town to another by wooden shoes. Incidentally, wooden shoes are almost unknown in the cities—contrary to prevailing opinion abroad. But there is the bicycle. The bicycle is used for shopping by house-wives; by youth going to school; by workers to their factories, and by clerks going to their offices. Indeed the bicycle is so much used that calculations for Amsterdam before the war indicated that a larger number of bicycles can hardly be expected. Not because the purchasing power does not suffice to buy more of this inexpensive vehicle, but simply because

the need for bicycles is almost completely satisfied. The saturation point has practically been reached.

Hence *public* means of transportation—street-cars and buses—are far from having the same range of patrons as in cities of the same class in other European countries, where often more than 300 journeys are made yearly per inhabitant—about three times more than in the largest cities of the Netherlands. One can say even that

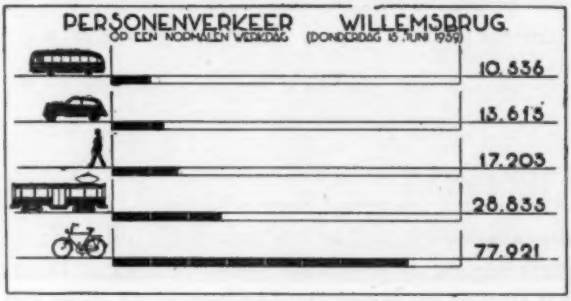


FIG. 1

there are fewer pedestrians, for many journeys made elsewhere on foot, are in Dutch cities made by bicycle.

Figure 1 shows in what manner the bridge connecting the river-sides at Rotterdam was crossed on a pre-war workday. More than 50 per cent of the public was crossing by bicycle. And comparison with other statistics showed that traffic on this bridge was a fair average for the whole or urban traffic, and also for other cities of the same size.

Reasons for fewer motorcars in the Netherlands than in the United States hold good in Europe generally: higher costs of both purchase and operation and a fiscal policy that does not encourage motoring. And of course the popularity of the bicycle lessens the need for motorcars.

In these circumstances, the traffic on streets in Amsterdam, Rotterdam and the Hague is quite different from the traffic in most other countries. Pre-war statistics show that traffic units appear on our urban streets in approximately the following proportions:

Motor Vehicles (slightly more private cars than trucks)	100
Ditto on 2 or 3 wheels	18
Trams	5
Horse-drawn vehicles and hand-driven carriages	5
Bicycles (a small number of transport vehicles on 3 wheels included)	550

But in rush hours, the number of cyclists grows to 1300 or more for every 100 motor vehicles. Scenes like that in photograph A are quite customary.

MAJOR PROBLEMS

This different aspect of traffic creates different problems. In order to simplify the picture, therefore, horse-traction and hand-driven push-carts, baby buggies, etc. will be omitted in the following discussion. These forms ought to be prohibited wherever they add to traffic difficulties that already are complicated by motorcars, street cars, cyclists and pedestrians.

The normal arrangement of vehicles is street cars on the left, motorcars in the middle, and bicycles in right-hand lanes. (See Fig. 2.)

What now become the consequences of stopping and parking?

Tramstops create no special problems though as in every city, the safety zones narrow the street space for other traffic. Curb-stopping or curb-parking of motorcars brings considerably more confusion. Curb-bound cars have to cross the lanes of the bicycles, and the operation, of course, has to be repeated when leaving the curb. When there is a parking strip to the right of the bicycle lanes, the parking and starting motorcar crosses only the cyclists' stream. Often this stream of cyclists has few if any gaps. Cars crossing it, therefore seriously affect the regularity of flow.

But consequences are still worse, when there is not such a strip; and, as a rule, there isn't. Bicycles in this case are hemmed in between arriving cars and the curb. When the cars start again, bicycles are chased from their lanes to the center of the road used by motorcars. Here they mix with motor traffic that must reduce its speed until the cyclists can re-gain their lane. These maneuvers are dangerous.

FIG. 2. A Right-Hand Cyclists' Lane

FIG. 3. Bicycle Complications

FIG. 6. Bicycles at a Stop-Sign

FIG. 7. Traffic in the Netherlands

Traffic accidents between motor vehicles and bicycles occur as often as between motorcars.

The problem thus created is particularly difficult. The advantage that curb-stopping motorbuses and trolley-buses have over street cars in American cities, is nullified in the Netherlands by the necessity of crossing the bicycle lane. The Watson suggestion[1] that tram tracks turn to the curb for stopping has no value for our cities.

Turning from this bicycle-complicated problem of curb-stopping, we find the problem of jockeying for position to turn at intersections just as complicated by *vehicles*.

In Paris, London, and numerous other cities where only motorcars fill the streets, all traffic units have about the same speed. When a driver wants to drive faster but is prevented by cars ahead, the restriction does not seriously inconvenience him. Each driver approaching a junction moves to the lane that best suits him: the left lane if he intends to turn left, the right, if he intends to turn right, the middle if he plans to go straight on.

This choice is made before the cross-street is reached and at the moment it can be effectuated without disturbing traffic. Thus when vehicles reach the intersection, the traffic is already grouped for directions the units will take. Usually the stream flows on without cars from the same street needing to cross one another's path.

But where cyclists are important road-users, a different procedure is necessary. First, traffic on the road is grouped according to normal unit speeds: bicycles together at the right; motor cars to the left. This grouping *must be maintained* until arrival at cross-streets. Jockeying for position can take place, therefore, *at* the intersection only. Intersections consequently are points of maneuvering as well as of turning; movement is more complicated than when jockeying has somewhat leisurely taken place on the stretch *before* the junction and without a stream of bicycles to take into account. Street cars on most main streets in the Netherlands, and in some places horse-drawn vehicles, further confuse the cross-street flow.

Differences in these cross-street movements are shown by schemes a, b, c, and d. Depending on whether one, two, three or four kinds of traffic are involved—motorcars only; motorcars *and* bicycles; etc.—

[1] H. Watson, Street Traffic Flow, London, 1933, p. 231.

the number of crossings among units coming from the same street at the intersection is respectively 0, 3, and 14 respectively!

Scheme *e* shows how relatively simple is an intersection where only one kind of traffic passes, and where consequently, the direc-

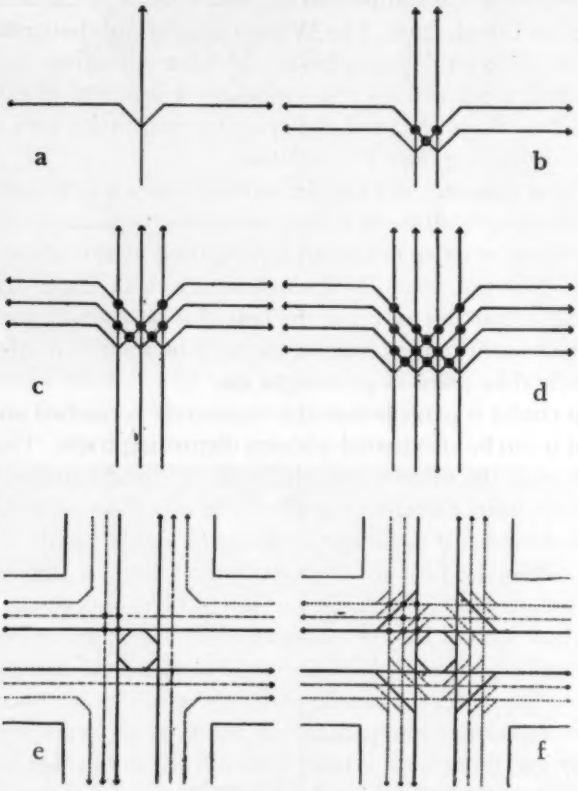


FIG. 4

tional grouping can take place before the time comes to turn. Scheme *f* shows how complicated the situation becomes when three different categories compel the grouping *at* the intersection itself. Not only the number of crossing-points rises from 4x4 to 4x9, but also the dividings and unions are more numerous: twenty-four instead of four!

Admittedly, the schemes are theoretical and in some applications extreme. In broad streets, bicycles turning left may sometimes get into the left-hand lane before reaching an intersection. But if motor traffic is heavy, cyclists seldom get in a left lane before the turn, and street-cars can never leave their tracks. In any case, the schemes get to the root of the problem. They show why in bicycle-cities, quickly congested intersections require traffic officers or traffic lights at a lower point of motor vehicle intensity than in cities with motorcars only.

Generally it is necessary to have special times for traffic to turn left. Otherwise, cyclists in a right hand lane but bound for the left are held up during the green phase while faster-moving motor vehicles and street-cars go straight on or turn right. Bicycle-riders must therefore have a left-turn phase. Long stop-phases are also a consequence of this heterogeneous traffic.

Even if a traffic plan allows the synchronizing of light signals for successive intersections—which in some countries is not always the case—this system can be of little help in the Netherlands because such synchronization functions on the basis of an approximately uniform speed for all traffic units. This uniform speed of course does not exist in our cities. So we have but one series of synchronized signals in operation—in a narrow Amsterdam street, where the distance between curbs is but 7.20 meters (23.622 feet).

The single set of street-car tracks in the middle of this Leidsche Straat is used by several lines in both directions. It is consequently seldom practicable to use this center strip for either bicycles or motor vehicles. Both classes of riders, therefore, have one lane of less than eight feet available on each side of the street-car tracks. Thus it is not often possible either to jockey for position or to pass before an intersection is reached. Here synchronized traffic signals on thirteen intersections are justified though some of them must have a slightly different cycle. The system is regulated on 18 km/h, (11.184 miles an hour), all the traffic being condemned to about the speed of the bicycles.

Where each kind of vehicle has its own lane—at least where bicycles are separated from the motor vehicles and street-cars—each road user can develop his most convenient speed. Synchronizing

would in that case compel fast traffic to wait at intersections for the slow, or cyclists would never reach a cross-street during the green phase and therefore would lose time at every light.

In the case of the narrow Amsterdam street, the heavy traffic is radial between the southern suburbs and the city, while cross traffic is relatively light. Long green-phases are consequently possible and a slow cyclist who could not follow the flow, will seldom more than once miss the green phase. He will therefore not have long to wait.

What does the *roundabout*[1] mean for the urban traffic in the Netherlands?

H. Watson[2] writes, thinking of England: "For intersecting the majority of main routes in the central area of large modern cities, the roundabout is supreme. It is essential to any ideal scheme, and is the crossing-of-the-future for general purposes. Low cost, little delay, ability to pass heavy traffic, freedom from the danger of collisions, architectural opportunities and easy supervision are its merits."

The scheme answers the question, if this praise holds good, when there are several kinds of road-users. All the crossings necessary are now to be made on the roundabout itself, though sometimes less sharp than is illustrated on the scheme. (Fig. 5) It is clear that when traffic consists of motor cars only, conditions are more favorable because the driver will enter the roundabout on the lane he considers best and the flows in the circle have the character of unions and dividings. But if traffic units must enter on the lane indicated by their speed (the inside lane being the faster), the great majority will have to cross the streams of other categories. This has at some points necessitated a traffic officer; and thereby is lost the greatest advantage of the roundabout—the steady flow.

Good results—a traffic that does not run stiffly—can therefore be expected only when the roundabout is much larger than would be necessary for motor traffic only, with large carriageways and favorable distances between the entering streets in order to have enough space to allow drivers to weave little by little into their lane. In our cities, however, large squares and circles are scarce so that a round-

[1] The English term for what in the U. S. is called a traffic circle or rotary traffic. Editor's note.

[2] H. Watson, Street Traffic Flow, London, 1933, p. 334.

about in the Netherlands can seldom possess the previously mentioned advantages of "ability to pass heavy turning traffic (and) freedom from the danger of collisions."

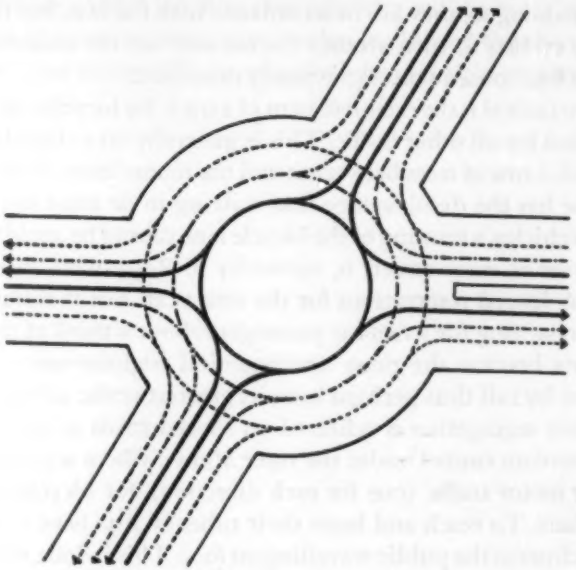


FIG. 5

SOLUTIONS

Since traffic intensity and road accommodation vary from city to city and from street to street, perhaps no panacea will ever be found for a traffic problem. Therefore it is difficult to indicate specific measures taken in the Netherlands to improve the flow and reduce the congestion incurred by the *typical kind* of traffic. Nevertheless the general trend is to segregate the different categories of road-users.

Many streets have along the curbs a special pavement of 1 or 1.5 meters in width. Perhaps this was constructed in earlier times to give bicycles a brick pavement. This provides a better surface for the bicycles than can usually be given to the motor traffic, because of the always moving soft soil in many parts of the country. And though one is not forbidden to drive a car in that lane, he generally avoids

doing so, and the pavement really helps to segregate the traffic. Of course this has not too great a significance in business streets where most drivers park their cars on the right side on this special pavement. In doing so, they are in accordance with the law, but their act compels cyclists to turn around the car and use the motorcar lane with the bad consequences previously described.

More radical is the establishment of a track for bicycles, definitely prohibited for all other traffic. This is generally on a slightly raised level with a row of trees between it and the motor lanes. This profile of course has the disadvantage that walking to or from stopped or parked vehicles, a crossing of the bicycle lane cannot be avoided. The segregation in main streets is, especially in Rotterdam, often completed by fenced reservations for the street-car, but it seems to me that by reserving for street-car passengers about a third of the road, street-cars become the most uneconomical highway-users. Transportation by rail thus perhaps loses its greatest traffic advantage.

Perfect segregation is achieved on special roads as for instance the Rotterdam tunnel under the river Meuse, where separate tubes exist for motor traffic (one for each direction), for bicycles and for pedestrians. To reach and leave their tube, cyclists have to use the same inclines as the public travelling on foot. This is done with great skill by nearly everyone. It may seem surprising to Americans that during rush hours, it is only the cyclists, not the other users of the tunnel who have to form a queue.

Last but not least: what about segregation at *intersections* where all measures to separate street-cars, motor cars and bicycles in the street are of no avail, (though it is here they would be of the greatest value). Actually, at intersections, all kinds of traffic are mixed up. As this mixing is the very cause of most congestion at junctions, the solution must be sought in some suppression of this mixing. This can be accomplished by creating separate intersections for fast and slow traffic at different levels. The consequence would be that on each level traffic would become homogeneous, and two roundabouts or traffic circles would be a good solution.

This radical, and perhaps surprising, suggestion will not be possible in the centers of towns that must serve modern traffic with street-plans three or more centuries old and where changes must be

made along more classical lines. We shall, however, rebuild central areas, industrial quarters and residential zones of several towns devasted by World War II. Here is an opportunity to put new ideas into practice. And I am sure that posterity will have no reason to reproach the present generation for having missed the chance to reconstruct our towns with sound principles and bold projects.

Traffic Accidents in 1947

SIDNEY J. WILLIAMS

Mr. Williams is assistant to the president of the National Safety Council, Chicago. He is a member of the Society of Automotive Engineers and a member of the Board of Consultants of the Eno Foundation. He is also a member of the American Society of Civil Engineers, of the Institute of Traffic Engineers, and a member or officer of numerous national committees in the traffic field.

AN ARTICLE in the Traffic Quarterly for April one year ago analyzed the 1946 traffic accident experience and pointed out the sudden drop in deaths and mileage death-rates. That drop began in May of 1946. It was attributed largely to the President's Highway Safety Conference and corollary activities. The article ended with this statement:

> The monthly deaths and death rate—and all other accidents—may bounce up again before this article is in print. Or they may continue downward. What happens in 1947 and thereafter will depend mostly on how well all of us do what we said we were going to do last May.

They didn't bounce up. The rate in fact continued downward, not spectacularly but quite consistently. Clearly, many officials, many organizations, many drivers and pedestrians did do what they said they would.

Nevertheless, traffic killed 32,000 persons.

Table I shows monthly death totals and mileage death-rates for 1946 and 1947, based on all data available at the end of January 1948. Traffic volume or total vehicle-mileage (not shown in the table) was higher throughout the year, by around 9 per cent. Deaths as well as death-rates in the first four months were substantially lower, because those months of 1946 had offered a big target to shoot at. In the remaining eight months deaths were sometimes up a little because of greater volume, sometimes down; but the *rate* was down in each month except July which showed no change. For these eight months the average death-rate was down only 0.7 or about 8 per cent under 1946—not a large figure, but better than 8 per cent up.

Table I

MOTOR VEHICLE DEATHS AND DEATH RATES

	Deaths		*Mileage Death Rates*	
	1946	*1947*	*1946*	*1947*
January	2920	2450	12.6	9.2
February	2610	2170	11.7	8.6
March	2820	2370	10.6	8.4
April	2520	2360	8.6	7.6
May	2540	2660	8.5	8.0
June	2350	2440	8.0	7.1
July	2530	2720	7.8	7.8
August	2930	3070	9.3	9.0
September	2770	2820	9.6	8.6
October	2990	2950	9.8	8.8
November	3110	2880	10.9	9.8
December	3320	3110	11.7	11.0
Total	33410	32000	9.8	8.6

Sources: 1946 total from National Office of Vital Statistics. All others, National Safety Council estimates from state reports. Rates based on Public Roads Administration mileage estimates.

Reductions Not Uniform

Was there a general reduction in accidents of various types all over the country? The answer is definitely No.

Urban traffic deaths decreased 28 per cent from 1941 to '47 and 18 per cent from 1946 to '47. For rural deaths, the figures are minus 15 per cent and plus four per cent.[1] These differences can be explained only in small part by a slightly greater increase in rural than in urban travel.

Since rural accidents primarily reflect statewide official and other activity, it must be concluded that in general the states are not yet doing as effective a job as the cities. There are obvious reasons, but the fact remains. The records of certain states, mentioned below, show what can be done—but not in a year or two.

[1] More complete data may change some of these and other figures slightly, but hardly enough to affect the conclusions drawn.

Pedestrian and Other Deaths

Pedestrian deaths decreased 26 per cent from 1941 to '47 and 15 per cent from 1946 to '47. For two-vehicle collisions the figures are minus 20 and plus 6. These differences are partly due to the urban-rural shift because most pedestrian deaths are in cities. Still, the substantial improvement in the pedestrian column indicates that current emphasis on safety for and by the pedestrian is bearing fruit. The actual increase last year in collisions of two motor vehicles is not so encouraging, though explainable by heavier volume of traffic.

Any analysis of the trend by age groups and by accident circumstances or causes must await more complete and accurate data.

States

Connecticut, Rhode Island, New Jersey and Massachusetts had 1947 death rates, on both mileage and population bases, slightly over *half* the national average. Iowa, Maine, Pennsylvania, Missouri, Vermont, Kansas, New Hampshire and New York averaged, on either basis, about 20 per cent below the country as a whole. The highest state death-rates were about four times the lowest. In general, the states with the lowest rates and the greatest reductions are those that have done the most comprehensive and persistent accident prevention work for the greatest number of years.

The recently adopted program of the State Officials' National Highway Safety Committee shows that the state officials, through their national associations, are accepting this challenge.

LOOKING AHEAD

The death total for the last eight months of last year was, on present estimates, about 100 greater than for the same period of 1946. The reduction for the year came entirely in the first four months. For the last eight months, the mileage death-rate went down just enough to balance the increase in traffic volume.

Even if we continue reducing the death-rate by a small per cent each year, and if we also continue overloading our highways in the

same ratio, we are on a treadmill—getting nowhere fast. The social cost of accidents—the chance that you, your wife or your child will be killed or crippled—depends not on rates but on numbers.

I for one do not believe that the American people will continue to tolerate each year 32,000 traffic deaths, to say nothing of the million or more injuries, many of them horribly serious, which have not even been mentioned in this article because the statistics are so incomplete.

The evidence is clear that while we have done much in recent years, we have not yet done enough. The most we can say is, we did not slip back.

One thing that will help is to build more and better streets and highways. Highway mileage should at least keep pace with vehicle mileage. The greater the highway mileage occupied by any given number of vehicles, the less chance is there for any two of them to collide. Still more important, we know that safety can to a large extent be built into highways and city streets. The other elements of the standard program are too well-known to need discussion here. The record proves that the program brings results.

Another thing we surely need is a sharpening of our knowledge, a refinement of the many engineering, enforcement and educational techniques comprised in the standard program. Hence the current task of a committee of the President's Highway Safety Conference, to formulate a comprehensive highway safety research program, is particularly timely. We already know that we can save lives in proportion to the time, effort and money we invest. Perhaps we can find out how to save even more lives with the same money.

The year 1947 was a critical one. It proved that the enthusiasm generated in May of 1946 was not just a flash in the pan. It proved also that all we are now doing is still not enough.

Everyone Has a Personal Stake in His City's Parking Problems

F. WARREN LOVEJOY

Mr. Lovejoy deals with activities of the State Highway Planning Survey of the Public Roads Administration. For years he has made a close study of urban parking facilities. He represented the Public Roads Administration in joint work with the New York Regional Plan Association during the Traffic and Parking Study in Manhattan and Brooklyn. Mr. Lovejoy also served as Executive Secretary of a Joint Committee on Parking in the District of Columbia. He is a member of the Project Committee on Parking of the Highway Research Board.

HAVE you ever thought about going into the parking business? Not by running a garage or parking lot, but by getting factually interested in parking—by seeking to understand parking facilities in general, what they can do for you whether you operate a private automobile or ride to work in street-car or bus.

Parking facilities are an indispensable part of highway transportation and highway transportation is life blood for the community of which all of us are part.

We read a great deal now about the parking problems that confront our urban areas since the war. We read of methods adopted to meet and solve these problems; of free parking here, of high-cost parking there, of parking-meters, fringe-lots, shuttle buses, garages.

But there is not yet a wide appreciation of the true functional purpose for which parking facilities are needed. Too few persons understand that the *non-car-owning* member of an urban community also has an important concern in parking provisions, and in their economic and efficient operation.

Parking Authority Is First Step

The purpose of cheap or free parking is plain enough in a small city that is trying to attract business from neighboring communities. So

is the need for convenient parking at isolated industrial plants, especially when sufficient mass transportation is lacking.

But where many private automobiles and considerable mass transportation operate, as in a large city, the specific use of parking facilities needs to be analyzed carefully before such facilities are provided. They should be dealt with effectively from the functional approach.

Since the solution of the parking problem in a large city is usually much more complicated than in smaller places where functional objectives are easier to see, let us imagine first that a parking authority has been installed to deal with the situation.

This authority has been named on account of the growing demand for parking and the mounting traffic congestion. Let us assume this parking authority is determined to deliver a workable plan to solve parking and congestion problems.

To begin with, the authority must gather accurate information regarding existing conditions. Reliable techniques have been developed for collecting and analyzing data affecting urban transportation by highway. The United States Public Roads Administration has contributed importantly in this regard and is constantly improving its field and office procedures. So our parking authority might well encourage the making of an over-all origin-and-destination study by modes of travel, or on the other hand it might rely solely on a parking survey.

Contents of Necessary Parking Data

The parking authority's survey would produce inventory information about parking spaces. Second, there should be origin-and-destination data concerning the parkers themselves. Third, and of high import in the final analysis, there should be material evaluating both current and potential demands for parking facilities created by different businesses, office buildings, stores, theaters, and other generators. These data on parking demands are basic in reaching logical conclusions.

Turning now to the actual parking facilities in our hypothetical city, we hope the parking authority will be given the control of them,

both on-street and off. In that way, their operation can be effectually coordinated. Such control is logical because parking facilities possess many of the characteristics of public utilities. Thus the parking agency would be able to decide how parking facilities could best be made to function permanently in the public interest.

Accessibility Is the Key Word

Looking over the functions that off-street parking facilities should perform in the community interest, the following might appear in several categories:

1. Maintaining or raising the level of tax revenue in the downtown, congested area.
2. Stimulating new building or building improvement in the downtown section.
3. Accelerating the flow of traffic through downtown streets.
4. Improving the service rendered by mass transportation.
5. Increasing downtown business in all lines.
6. Reducing accident hazards on downtown streets.

Off-street parking facilities, therefore, in conjunction with the removal, where necessary, of on-street parking can be thought of as *downtown traffic congestion removers,* traffic accelerators, accessibility retrievers.

If the parking authority were asked to pick one word to express in essence the goal for which it is striving, it would undoubtedly select *accessibility*—accessibility of the city not simply to automobiles but to people by all means of highway transportation for which they are willing and able to pay—in order that the city can serve its concentration of business and industry.

Let us balance the picture by appraising the efforts of our parking authority and the effect of properly functioning parking facilities in terms of our benefit as city inhabitants. Viewed broadly, the social and economic benefits of cities when transportation facilities including parking are at high level, would present this sort of picture:

1. Large cities provide opportunity for an effective concentration of service industries.

2. Commercial and retail services, usually segregated in sections, offer opportunity for a wide range of price, quality, material and design.

3. Cities and their environs, because of population concentration, function for a full development of manufacturing.

4. On the social side, big cities provide unrivaled advantages in culture, music, art, and general entertainment.

5. For the professions the city offers large fields of endeavor, and furnishes a concentration of professional service and opportunity.

6. On the financial side, the city furnishes banking and other financial institutions, exchanges and the like.

Parking Authority's First Goal

There are those who believe that the principal function of cities will increasingly become the provision of service industries. However this may be, there can be no doubt that commercial, retail, and other services are the principal activities in the congested centers of big cities, the places where accessibility must be won back, and traffic congestion reduced.

So the parking authority would want first to see the establishment of off-street parking facilities in downtown sections, where unfortunately land values are high and where suitable locations are hard to find. The authority's program would probably contemplate the construction of one off-street unit, perhaps two or three, of suitable capacities and locations, as indicated by their survey of parking demands generated by various land-uses. The parking authority would then wish to observe the effect of these off-street facilities upon the parking demand before proceeding with a broader program.

Once having settled upon the capacities, types, and proper locations of downtown off-street facilities, the parking authority would want to implement its program, and decide whether to rely on private enterprise or public agency for necessary facilities.

In the United States, the tendency is to favor private enterprise. Private enterprise in the garage business is frequently a divided undertaking: first comes the private investor who builds the facility, then the operator who leases it from the investor-owner. Even when

municipal *building* is believed advisable, therefore, private enterprise in parking could continue, because a facility built by a municipality could be *leased* to a private operator.

Is Zoning the Answer?

One school of thought holds that the way to provide off-street parking facilities in downtown sections is through zoning, to require parking generators to furnish off-street space for their customers, patrons, or occupants. Another school replies that zoning could conceivably create special-service parking facilities that might be uneconomic, and if required, might exert a retarding influence on downtown building construction and improvement. This dissenting school points out that zoning, through numerous parking facility entrances, often in undesirable places, might also set up frictions against traffic movement. Even opponents of zoning will agree, however, that a zoning requirement for off-street loading and unloading space for commercial vehicles appears reasonable enough, and certainly would relieve street congestion.

Beyond the possibility of uneconomic and congestive effects of requiring off-street parking facilities by downtown businesses, stores, theaters, banks, etc., there is something fundamental to be said. Since a big city concentrates a supply and demand for commercial, retail and professional services, for music, art, finance and manufacture—not the only supply and demand for these things, but a concentrated one—the making efficient of this concentration through improved accessibility is a civic responsibility and basic reason for our parking authority.

Harking back to the functional value of parking facilities as retrievers of downtown accessibility, it seems that business activities in the central area could logically bear part of the cost of the parking facility spread over a period of years. This cost would come as special assessments on land uses. The amount would depend upon the relative parking demands generated as determined by the parking authority's survey. But the parking authority would know that most of the responsibility for making the central area function properly rests with the city itself.

The Question of Finance

Let us hope that both our parking authority and the city it serves will wish to go forward vigorously toward solving the parking problem, starting where the need is greatest, in the downtown congested area.

How shall new downtown off-street facilities be built? With public or private funds, or with a combination of both?

These questions were asked about the financing of bridges and roads, when the country found itself poor after the Revolution. Communities raised money for bridges by running lotteries, and authorized private enterprise to build toll-roads. These pay-roads were built in what looked like the best-paying locations, just as private investors today want to build off-street parking facilities only where parking demand is sufficiently heavy to assure good profit. Breaking even, possibly losing a little now and then, or low profit, merely to gain accessibility for an area, is not good business, when only the parking facility itself is involved. Business-group aid or municipal aid is often needed to provide enough parking to make downtown transportation efficient.

Probably it is equally true that most large municipalities would find it difficult to finance a full program of off-street parking facilities. But to progress toward the goal of accessibility, the city, it would seem, should through the parking authority use its right of eminent domain to acquire proper sites for off-street facilities. Whatever method is then used to finance parking structures on the downtown sites, those structures should revert eventually, if not at once, to municipal ownership and control. Operation, however, should be private. The parking authority would lease the completed facilities to private operators, stipulating the kind and quality of service to be given the public, including parking rate schedules.

Proper Sites and Proper Rates

Parking facilities are made to function properly by two positive means: first by selecting proper locations for the desired functional results; second, by setting rate schedules designed to get these re-

sults. The long-time parker can be served by the operation of off-street parking lots in a proper pattern at the periphery or fringe of the business and shopping district, coordinated with suitable mass transportation facilities for the final stage of the trip downtown.

But the fringe-lot cannot successfully serve the short-time business-customer parker, unless the site is reasonably close in and the bus or other mass transportation service is furnished frequently enough throughout the day. The cost of such frequent shuttle service may make it impracticable. Only to the extent that fringe-lots actually keep traffic out of the downtown area are they contributing significantly toward the ultimate goal of improving accessibility to business districts that would otherwise be congested.

Again, therefore, let our parking authority press first for downtown off-street facilities to attract the short-time parker and discourage by effective rate schedules a congesting use of these downtown facilities by long-time parkers. And there should be an orderly, well-conceived program for bringing back accessibility to all congested areas. The most costly part of the problem, though not all of it by any means, will be in downtown areas. Congested up-town or outlying districts should also be relieved as an important part of any parking plan. This effort should have singleness of direction through a central parking authority.

In that way, business can be made accessible to customers, theaters to patrons, stores to shoppers, professions to clients. And thus everyone, car-owner or not, has an important stake in the parking business of his community.